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DRAFT
Discharge Assessment Report
Hull Coating Leachate

August 2003

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DISCHARGE ASSESSMENT REPORT

Hull Coating Leachate

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Naval Sea Systems Command
U.S. Department of the Navy

Office of Water
U.S. Environmental Protection Agency

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LIST OF ACRONYMS

BCC	Bioaccumulative Contaminants of Concern
CFR	Code of Federal Regulations
ChAR	Characterization Analysis Report
CWA	Clean Water Act
DAR	Discharge Assessment Report
DoD	Department of Defense
EEA	Environmental Effects Analysis
EEAR	Environmental Effects Analysis Report
EPA	Environmental Protection Agency
FIAR	Feasibility Impact Analysis Report
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HI	Hazard Index
HQ	Hazard Quotient
MPCD	Marine Pollution Control Device
MSC	Military Sealift Command
MSDS	Material Safety Data Sheets
NAVSEA	Naval Sea Systems Command
NRL	Naval Research Laboratory
TBT	Tributyltin
TPE	Toxic Pound Equivalent
UNDS	Uniform National Discharge Standards
UNDSMIS	Uniform National Discharge Standards Management Information System
USCG	United States Coast Guard
VOC	Volatile Organic Compounds
WQC	Water Quality Criteria

1 Introduction

Section 312 of the Federal Water Pollution Control Act [also known as the Clean Water Act (CWA)] requires that the Secretary of Defense and the Administrator of the U.S. Environmental Protection Agency (EPA) develop Uniform National Discharge Standards (UNDS) for "…discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces…" [CWA Section 312(n)(1)]. UNDS is being developed in three phases. The first phase determined which vessel discharges require control by marine pollution control devices (MPCDs). MPCDs can be equipment, alternative materials, or management practices. The second phase, which this report supports, characterizes each discharge and evaluates the environmental effects and feasibility of implementing MPCDs for each discharge that requires control. The final phase will determine the design, construction, installation, and use of the MPCDs.

Discharge Assessment Reports (DARs) are prepared for each discharge requiring control as listed in the Title 40 Part 1700 Code of Federal Regulations (CFR). A DAR is a summary of discharge-specific analyses conducted during the second phase of UNDS. The purpose of the DAR is to present key features of a discharge to allow the balancing of the seven statutory considerations to produce a performance standard. The seven considerations are:

- the nature of the discharge,
- the environmental effects of the discharge,
- the practicability of using the MPCD,
- the effect that installing or using the MPCD would have on the operation or the operational capability of the vessel,
- applicable U.S. law,
- applicable international standards, and
- the economic costs of installing and using the MPCD.

In Phase I, it was determined that the Hull Coating Leachate discharge requires control by an MPCD (40CFR§1700.4). The following is a list of technical documents prepared for the Hull Coating Leachate discharge, and the complete analysis of this discharge can be found among various documents cited throughout this summary:

- *Vessel Grouping and Representative Vessel Selection for Hull Coating Leachate Discharge* (EPA and Navy, 2003c);
- *Characterization Analysis Report: Hull Coating Leachate*, hereafter referred to as the *Hull Coating Leachate ChAR* (Navy and EPA, 2003a);
- *Feasibility Impact Analysis Report: Hull Coating Leachate*, hereafter referred to as the *Hull Coating Leachate FIAR* (Navy and EPA, 2003b);
- *Environmental Effects Analysis Report: Hull Coating Leachate*, hereafter referred to as the *Hull Coating Leachate EEAR* (Navy and EPA, 2003c);
- *Hull Coating Leachate MPCD Screen, MPCD Option Group: Advanced Antifouling Coatings* (EPA and Navy, 2002a);

- *Hull Coating Leachate MPCD Screen, MPCD Option Group: Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings* (EPA and Navy, 2003a);
- *Hull Coating Leachate MPCD Screen, MPCD Option Group: Foul-Release Coatings* (EPA and Navy, 2003b); and
- *Hull Coating Leachate MPCD Screen, MPCD Option Group: Non-Coating Methodologies* (EPA and Navy, 2003d).

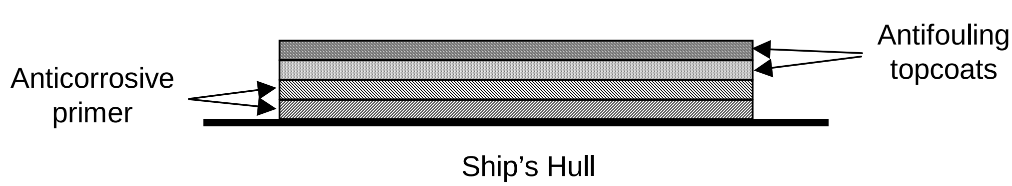
A review of applicable U.S. law and international standards and cost-effectiveness information that relates the results of environmental effects to feasibility analyses are also topics in this report.

1.1 Hull Coating Leachate Definition

In 40 CFR Part 1700, the Uniform National Discharge Standards (UNDS) for vessels of the Armed Forces defined hull coating leachate as "…constituents that leach, dissolve, ablate, or erode from the paint on the hull into the surrounding seawater." The Hull Coating Leachate discharge was determined to have the potential for adverse environmental effects largely because of the estimated copper loadings from hull coatings; and therefore, was considered for further action in the UNDS process (Navy and EPA, 1999).

A variety of underwater hull coating systems exist in the Armed Forces. Some vessels do not have coatings applied while others have coating systems consisting of base anticorrosive coats and antifouling topcoats as depicted in Figure 1-1. For the purpose of this analysis, only vessels with coatings to control fouling by marine organisms are included (i.e., antifouling and foul-release coatings). Marine fouling on a vessel is undesirable because it increases vessel drag, reduces ship speed, and increases fuel consumption.

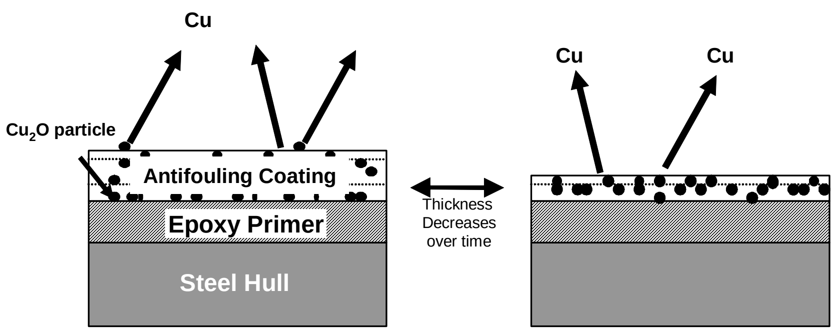
Figure 1-1. Typical Antifouling Paint System



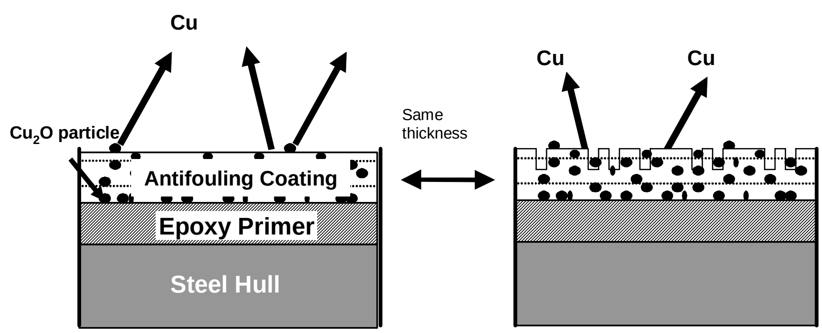
Each branch of the Armed Forces has a different process for procuring antifouling and anticorrosive coatings. The Navy requires that all coatings are tested and satisfy requirements described in MIL-PRF-24647, Performance Specification – Paint System, Anticorrosive and Antifouling, Ship Hull. The U.S. Coast Guard requires that all coatings meet the specifications of the U.S. Coast Guard Coatings and Color Manual. The Army, Military Sealift Command (MSC), and Air Force specify vessel coating requirements in their purchase orders.

Antifouling coatings typically contain biocides based on copper and zinc compounds that dissolve in water to prevent growth of marine biofouling organisms (e.g., barnacles, tube-worms, algae, etc.) on hulls. Copper ablative coatings and vinyl antifouling coatings are the types of antifouling coatings predominately used by the Armed Forces. Vinyl antifouling coatings release copper that is exposed by leaching and hydrolyzing of rosin. Ablative coatings are designed to wear or ablate away as a result of water flow over a hull. Figure 1-2 illustrates the difference between the release mechanism of ablative and vinyl coatings. Foul-release coatings, typically based on silicone resins and oils, are also used on a few Armed Forces vessels to inhibit the adhesion of fouling organisms to the hull by creating a surface to which organism cannot easily adhere. However, while a vessel is pierside, organisms readily attach to the foul-release coated hull and are only dislodged after a vessel gets underway.

Figure 1-2. Illustration of Ablative Coating and Vinyl Antifouling Coating Mechanisms



Ablative Coating Mechanism: Coating wears away exposing Cuprous Oxide (Cu_2O)



Vinyl Antifouling Coating – Copper Leaching Mechanism: Surface dissolving nonuniformly.

1.2 Relevant U.S. Law and International Standards

This section describes relevant U.S. (including State and Tribal) law and International standards that pertain to the Hull Coating Leachate discharge. The UNDS regulatory development process was designed to consider the seven rulemaking considerations presented in Section 1.0. Two of the seven considerations for developing UNDS performance standards are U.S. law and International standards.

1.2.1 Relevant International Standards

In 1999, the International Maritime Organization (IMO) adopted a resolution to address the use of organotin compounds in antifouling systems. According to an IMO publication, "the resolution called for a global prohibition on the application of organotin compounds which act as biocides in anti-fouling systems on ships by 1 January 2003, and a complete prohibition by 1 January 2008" (IMO, 2003). Ratification of this treaty instrument is pending.

International standards have not been developed for copper-containing antifouling paints. While they are not international standards, two countries, Canada and Sweden, have established maximum copper release rates for antifouling paints.

1.2.2 Relevant U.S. Law

In 1988, the U.S. established a maximum allowable release rate of 4 $\mu g/cm^2/day$ for coatings containing tributyltin (TBT) or organotin compounds (33USC§2402). Antifouling coatings with organotin (i.e., TBT) compounds are no longer used on Armed Forces vessels. The last documented TBT-containing antifouling coating was removed from a Navy ship in 1994 (Ingle, 2002).

U.S. standards have not been developed for copper-containing antifouling paints. However, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Public Law 95-396) requires the registration of antifouling biocides and antifouling coatings before the products can be marketed or sold.

2 Vessels Generating Hull Coating Leachate Discharge

Some vessels of the Armed Forces do not generate hull coating leachate. As previously stated, only vessels with hulls coated to control fouling are included in this discharge. Vessels that are either unpainted or are painted with an epoxy anticorrosive coating are not included in the Hull Coating Leachate discharge. DoD estimated that 3,104 Armed Forces vessels contribute to the Hull Coating Leachate discharge worldwide. To perform the necessary analysis for assessing the regulatory options, vessels that produce hull coating leachate were sorted into three vessel groups. Additional information regarding the vessel groups and selection of representative vessel class is contained in the *Vessel Grouping and Representative Vessel Selection for Hull Coating Leachate Discharge* (EPA and Navy, 2003c).

The category with the largest wetted-hull surface area is the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, which encompasses most Armed Forces vessels. Considerable variability in size and design is found among vessels in this group. Vessels in this group range from small boats to aircraft carriers over 1,000 feet long. The main factor in grouping these vessels is that they predominately use copper-containing antifouling coatings. For the purposes of these analyses, the USS NIMITZ (CVN 68) Class of aircraft carrier was selected to facilitate analyses for this class because:

- as a vessel type, aircraft carriers have among the greatest wetted-hull surface area of this vessel group;
- all aircraft carriers use standard copper ablative coatings; and
- the CVN 68 Class vessels are still under construction and are expected to remain in service for decades.

The second category is the Flexible (Non-Aluminum) Hulls vessel group, which consists of vessels that have hulls covered with flexible elastomeric materials. This vessel group is entirely comprised of Navy vessels that operate only in saltwater areas. Navy technical guidance requires the use of copper-containing antifouling coatings listed in Class 3A (Paint Systems having antifouling topcoats containing only copper-based toxics for use on rubber) of specification MIL-PRF-24647 for most flexible hulled vessels. The Flexible Hulls vessel group includes 58 submarines distributed among three classes and the MCM 14, a mine countermeasure vessel in the AVENGER (MCM 1) Class (Mine, 2002). Copper ablative coatings are the primary antifouling coating used on this vessel group, but these coatings are known to crack as a result of the elastomer compressing more than the antifouling coating when the vessel dives to operating depth. The cracking of these coatings is an ongoing maintenance issue. The Navy has active efforts to identify more flexible antifouling coatings for use on flexible hulls. The USS LOS ANGELES (SSN 688) Class of attack submarines was selected as the representative vessel class for this group, because:

- all submarines use standard copper ablative coatings;
- as a vessel type, submarines have among the greatest wetted-hull surface area and mass loading in this vessel group;
- the SSN 688 Class accounts for 51 of the 58 submarines in the Navy; and
- the SSN 688 Class is expected to exist for decades.

The third category is the Aluminum Hulls vessel group, which includes numerous classes of smaller vessels used by the Armed Forces ranging from less than 20 feet in length to 192 feet long. Vessels in this group primarily use non-copper coatings such as foul-release and antifouling coatings that use zinc oxide or non-metallic biocides. The U.S. Coast Guard's (USCG) 47-foot Motor Lifeboat (MLB 47) was selected as the representative vessel class for this vessel group, because:

- all motor lifeboats that contribute to the Hull Coating Leachate discharge use advanced antifouling or foul-release coatings;
- as a vessel type, motor lifeboats have among the greatest wetted-hull surface area and mass loading of this vessel group;
- the MLB 47 Class accounts for 98 out of 403 vessels in this vessel group; and
- the MLB 47 Class vessels are expected to be in service for decades.

3 Overview of Discharge Analyses

An overview of the approach to characterizing the Hull Coating Leachate discharge and performing the feasibility and environmental effects analyses are presented in the following sections.

3.1 Characterization of Discharge

Characterizing the baseline and MPCDs discharges for each vessel group of the Hull Coating Leachate discharge was necessary to perform the environmental and feasibility analyses. Information on the release of constituents and maintenance practices and operation of vessels was needed to initiate the analyses.

Coating constituents were identified using coating manufacturers' Material Safety Data Sheets (MSDSs); while government and manufacturer studies supplied information regarding the release of certain constituents. An assumption was made that the release rate of a constituent was proportional to the weight percentage of that constituent in the coating. This allowed release rate estimates for constituents to be scaled from known metal release rates.

In addition to specific constituent data, descriptive information (e.g., color, floating materials, odor, settleable materials, turbidity/colloidal matter, etc.) is normally used to fully characterize a discharge. Hull coating leachate is not discharged from a pipe, but slowly released from the entire underwater hull of a vessel. Existing studies have not collected or reported any descriptive information. As a result, descriptive information is not reported in this document. Due to the rate and nature of the constituents released, this discharge is expected to have negligible affects on parameters related to narrative water quality criteria.

A variety of information was necessary to quantify the magnitude of the discharge. Information from service representatives and equipment experts were used to identify the coatings used on each vessel class. Vessel movement information was obtained from the Uniform National Discharge Standards Management Information System (UNDSMIS) database to determine when vessels contribute to the discharge (i.e., days in port, days in transit) and at what rate (i.e., dynamic release rates when vessels are in transit, static release rates when vessels are pierside). Knowledge regarding vessel use and operation was also required when quantifying the amount of hull coating leachate. A detailed description of the coating constituents and release properties resulting from hull coating leachate is presented in the *Hull Coating Leachate ChAR* (Navy and EPA, 2003a).

3.2 Potential Marine Pollution Control Device Options and Screen Results

Potential MPCD options to control Hull Coating Leachate were identified through a variety of sources including current practices of Armed Forces vessels and commercial vessels as well as literature and Internet searches. Four MPCD options were identified and screened to determine which MPCDs have been sufficiently proven for controlling hull coating leachate. A brief description of each MPCD option and the results of the screen are provided below.

3.2.1 Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings

For Armed Forces vessels coated with antifouling products qualified under the military specification MIL-PRF-24647, the biocide released into the water to prevent the growth of marine fouling organisms is the copper from cuprous oxide or other copper-containing compounds included in the coatings (Navy, 2001). This MPCD option group would establish a maximum allowable copper release rate from copper-containing antifouling coatings. A numerical maximum allowable copper release rate standard would be based on the results of ongoing Navy testing using the American Society for Testing and Materials (ASTM) D 6442, *Standard Test Method for Copper Release Rates of Antifouling Coating Systems in Seawater*. If this MPCD option group is chosen, it will prevent the use of higher release rate copper-containing coatings in future applications.

Once the maximum allowable copper release rate is established, the limit would be applied to current and future antifouling coatings. Coatings that emit more copper than allowed, as measured using the ASTM-D-6442 test method, would be prohibited from use on Armed Forces vessels.

A precedent exists for establishing a maximum allowable release rate for copper. In 1994, Canada established a copper release rate of 40 $\mu g/cm^2/day$ for all coatings being registered through Health Canada (Health Canada, 1994). Sweden also established a copper release rate of $55 \mu g/cm^2/day$ for all vessels operating in the Baltic and North Sea areas (International Coatings, 2000).

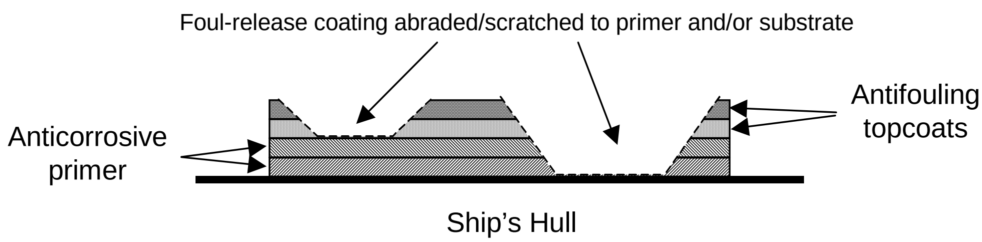
The establishment of a maximum allowable copper release rate for antifouling coatings has been demonstrated in foreign countries. Therefore, this MPCD option passed the MPCD screen as outlined in the *Marine Pollution Control Device Screen Criteria Guidance Document* (EPA and Navy, 2000b).

3.2.2 Foul-Release Coatings

A standard based on the foul-release coatings MPCD option would mandate the use of foul release coatings on all vessels within an appropriate vessel group. The foul-release coating approved for Armed Forces vessels is a soft flexible material based on silicone polymers that uses surface chemistry to inhibit adhesion of fouling organisms to the hull coating. This coating exhibits a low surface energy and is applied as extremely smooth layers, such that any marine organisms that grow on the hull can be released or dislodged by the flow of water over the hull as the vessel achieves a critical speed (i.e., usually in excess of 15 knots). Foul-release coatings do not release biocides to control fouling (NRL, 1997).

Foul-release coatings have no means of preventing the growth of marine fouling organisms (e.g., algae, mollusks, worms, etc.) while vessels are pierside. As little as two weeks of vessel inactivity (i.e., no instances of operations above the critical speed for fouling release) in high-fouling areas (e.g., Miami, FL and Ingleside, TX) can result in build-up of marine fouling organisms on a vessel's hull requiring a complete hull cleaning (International Marine Coatings, 2001). Because vessel motion is required to dislodge the marine fouling from the hull, vessel speed is an important factor when considering the vessel classes or types that can successfully use foul-release coatings. When the vessel's operational profile does not provide sufficient operating time and speed to dislodge fouling organisms, underwater hull cleaning is usually required (International Marine Coatings, 2001; Hempel, 2001; Marlin Paint, 2001). Even careful cleaning of the soft foul-release coatings can result in scratch damage that could negatively affect their efficacy. Scratches from cleaning or abrasions from fenders or tugs can expose the epoxy primer or substrate under the foul-release coating as shown in Figure 3-1. These damaged areas will foul, and a more significant cleaning effort will be required to remove organisms from the epoxy substrate, resulting in a greater degree of damage to the foul-release coating. Thus, the degradation of the coating accelerates and the efficacy of it declines rapidly once the surface smoothness has been compromised.

Figure 3-1. Damage to Foul-Release Coatings



Foul-release coatings are currently approved for use on Armed Forces vessels in accordance with MIL-PRF-24647. Intersleek 425 foul-release coating is currently used on a limited number of Navy and Coast Guard vessels. Therefore, this MPCD option group passed the MPCD screen as outlined in the *Marine Pollution Control Device Screen Criteria Guidance Document* (EPA and Navy, 2000b).

3.2.3 Advanced Antifouling Coatings

The advanced antifouling coatings MPCD option would mandate the use of such coatings on all vessels within a vessel group. Advanced antifouling coatings release short half-life biocides into the water surrounding the vessel hull to prevent the growth of marine fouling organisms. Some advanced antifouling coatings contain copper and a non-metallic co-biocide, while others are based on combinations of non-metallic biocides (e.g., Sea-Nine211®). Advanced antifouling coatings are currently being tested on Armed Forces vessels. The USCG has approved one copper-free antifouling coating for use on smaller USCG vessels with aluminum hulls. The USCG-approved, copper-free coating performs effectively for less than two years in high fouling areas such as Florida. At present, advanced antifouling coatings have been shown to foul too quickly and do not satisfy the Navy performance requirements in MIL-PRF-24647 (Lawrence, 2003). In the case of advanced antifouling coatings that use copper as a co-biocide, the Navy has stated that the advanced antifouling coatings should emit less copper than is currently released from the copper-ablative products approved under MIL-PRF-24647 to be considered an environmentally acceptable product by the Navy (Ingle, 2002).

Advanced antifouling coatings are currently approved and used on USCG aluminum small boats and craft. Future technological advances may allow the use of these coatings on ships that use copper ablative antifouling coatings. Therefore, this MPCD option group passed the MPCD screen as outlined in the *Marine Pollution Control Device Screen Criteria Guidance Document* (EPA and Navy, 2000b).

3.2.4 Non-Coating Methodologies

The non-coating methodologies MPCD option group included alternative methods, devices, or equipment that claim to eliminate or minimize the discharge of hull coating leachate by replacing conventional hull coatings. The methodologies and devices reviewed are grouped in the seven categories: (1) electrical & electrochemical devices, (2) acoustic and ultrasonic devices, (3) radiological devices and treatments, (4) surfaces with micro and/or macroscopic topology, (5) containment systems, (6) metal spray/claddings, and (7) alternative alloy hulls.

Non-coating, fouling-control methodologies and devices have not been proven effective on modern commercial or Armed Forces vessels. Therefore, this MPCD option failed the MPCD screen as outlined in the *Marine Pollution Control Device Screen Criteria Guidance Document* (EPA and Navy, 2000b).

3.2.5 MPCD Screening Results

A summary of the MPCD options identified and the outcome to the MPCD analysis are presented in Table 3-1.

Table 3-1. Hull Coating Leachate MPCDs Identified

MPCD	Result
Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings	Pass
Foul-Release Coatings	Pass
Advanced Antifouling Coatings	Pass
Non-Coating Methodologies	Fail

Additional information on these MPCD options and the screen analysis can be found in the respectively titled MPCD screen reports (EPA and Navy, 2002a, 2003a, 2003b, and 2003d).

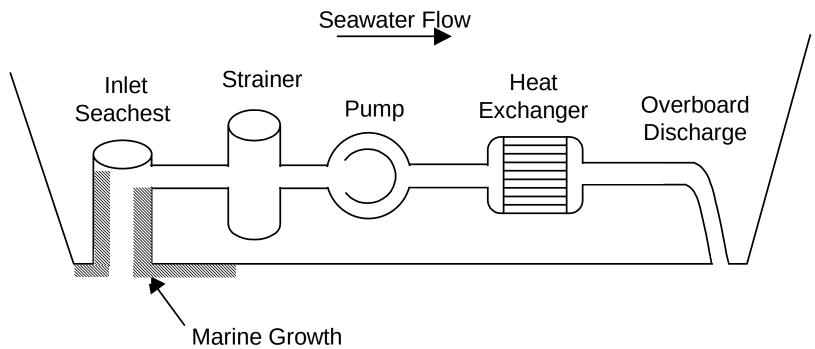
3.3 Feasibility Impact Analysis

The analysis of discharge information and presentation of results in this report are in accordance with the methodology contained in the FIAR guidance manual (Navy and EPA, 2000b). Five feasibility factors were applicable to the Hull Coating Leachate discharge including one factor (i.e., drydocking interval and pierside maintenance factor) identified as unique to this discharge:

- Mission Capabilities,
- Drydocking Interval and Pierside Maintenance,
- Initial Costs,
- Recurring Costs, and
- Total Ownership Costs.

Vessel operational area and mission influence the selection of hull coating system. The potential impact that each MPCD would have on each vessel group was analyzed after obtaining information from shipyards and technical experts. The feasibility analysis explores the effect of each MPCD option on a vessel's mission capabilities. In addition to coatings being applied to hulls, the seachests on some vessels are coated with the hull paint system. Any changes to the hull paint system have a direct impact on marine growth surrounding the seachest and the related ship systems. Increased growth in the seachest area may enter the seawater system affecting the operation of the ship heat exchanger and the systems they support as illustrated in Figure 3-2.

Figure 3-2. Typical Seawater System



The feasibility analysis also examines the change in vessel drydocking cycles and required pierside maintenance. Each MPCD option has a different service life and could result in drydock and maintenance cycle changes.

The final step of the feasibility analysis estimates costs for implementing each of the MPCD options. Costs include modifications to the existing military specifications, manuals, and contracts as well as direct expenses for the preservation of ships (i.e., drydocking, procurement of coatings, disposal of solid waste, and any other coating related expenses).

A more detailed discussion of the feasibility impact analyses is included in the *Hull Coating Leachate FIAR* (Navy and EPA, 2003b).

3.4 Environmental Effects Analysis

The environmental effects analyses (EEA) entail seven tasks that are summarized below. The specific analyses to be performed are outlined in the *Environmental Effects Analyses Guidance* (EPA and Navy, 2000a).

3.4.1 Comparison to Water Quality Criteria

From the information contained in the *Hull Coating Leachate* ChAR, a series of analyses were conducted. Constituents were identified with estimated concentrations at 1 cm from the hull that exceeded any State or Federal numeric acute or chronic water quality criteria standards. Due to the lack of descriptive (i.e., narrative) data, comparisons to narrative water quality criteria standards were not conducted. Due to the rate and nature of the constituents released, this discharge is expected to have negligible affects on parameters related to narrative water quality criteria.

3.4.2 Discharge Toxicity

The toxicity of the discharge was evaluated by estimating acute marine aquatic-life toxicity at the 35m edge of the mixing zone. For the Hull Coating Leachate Discharge, transect data around a hull was available and used in place of modeled data to estimate concentrations at the 35m edge of the mixing zone to calculate the Hazard Index.

3.4.3 Identification of Bioaccumulative Contaminants of Concern

Coating constituents were identified that are included on the list of bioaccumulative contaminants of concern (BCCs) designated for reduction by U.S. permit and clean-up programs.

3.4.4 Mass Loadings/Toxic Pound Equivalent

Mass loadings were calculated for active vessels of the Armed Forces homeported in the U.S. while in port and while underway within 12 nm using constituent static and dynamic release rates, vessel time pierside and in transit, and vessel coating usage information. The length of the vessel was also an important factor, because vessels less than 25 feet in length are frequently pulled out of the water during the time pierside and do not contribute to loadings while they are out of the water. The mass loadings were used in conjunction with toxic weighting factors to calculate toxic pound equivalent (TPE) loadings.

3.4.5 Release of Nonindigenous Species

A qualitative evaluation of the baseline discharge and MPCD options' potential to introduce nonindigenous species of plant and animal life into new environments is an important factor for the environmental effects analysis.

3.4.6 Other Potential Environmental Effects

In addition to constituent analyses, other potential environmental impacts of the discharge were identified. These impacts include any additional air releases, solid waste generation, or energy requirements of the options.

4 Summary of Impacts – Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

The largest vessel hull category (i.e., most vessels and wetted hull area) to be evaluated for the Hull Coating Leachate discharge is the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group. Approximately 2,600 vessels are included in this group with a total wetted surface area of 2.5×10^7 square feet. The vessel group accounts for 85% of vessels that produce this discharge and 91% of the total wetted hull surface area (of vessels that produce the Hull Coating Leachate discharge). The USS NIMITZ (CVN 68) was chosen as the vessel class on which to conduct analyses for this group.

4.1 Characterization of Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Approximately 86% of vessels in the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group use copper ablative antifouling coatings, while the remaining 14% of vessels use vinyl antifouling coatings (Shimko and Tock, 2003). The baseline discharge from this vessel group is a result of constituents leaching from these coatings. A combination of information received from coating manufacturers and government studies are the basis for all estimated and calculated concentrations and release rates. Copper ablative coatings have an estimated service life of 12 years on a USS NIMITZ class vessel.

Constituent concentrations at 1 cm from the hull and release rate information for the baseline discharge are presented in Table 4-1. As discussed in the *Hull Coating Leachate ChAR*, any volatile organic compounds (VOCs) present in coatings were assumed to dissipate during the coating drying/curing process and are not included in the list of constituents discharged from the various coatings characterized.

Table 4-1. Constituent Information for the Baseline Discharge of the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (µg/l)	Release Rate (µg/cm²/day)		Constituent Mass Loading (lb/vessel group-year)	TPE (lb-equiv/yr)	BCC Identified
		Static	Dynamic			
Copper Ablative Coatings						
Total Copper	5.3[b]	8.9[b]	17.0[b]	99,000	180,000	Reduction
Total Iron	0.26[c]	0.44[c]	0.84[c]	4,900		No
N-ethyltoluenesulfonamide	0.31[c]	0.52[c]	1.2[c]			No
Plasticizer	0.28[c]	0.47[c]	1.1[c]			No
Polyamide resin	0.28[c]	0.47[c]	1.1[c]			No
Rosin	1.0[c]	1.6[c]	3.8[c]			No
Total Zinc	2.1[c]	3.6[b]	6.7[b]	40,000	2,700	Reduction
Vinyl Antifouling Coating						
Total Copper	6.8[c]	12[c]	22[c]	22,000	39,000	Reduction
N-ethyltoluenesulfonamide	0.68[c]	1.1[c]	2.2[c]			No
Rosin	2.2[c]	3.7[c]	6.9[c]			No
Vinyl Chloride-Vinyl Acetate Copolymer	0.68[c]	1.1[c]	2.2[c]			No

[a]Manufacturer information.
[b]Previous Navy Studies.
[c]Scaled from weight percentage or known release rate.

A complete description of the information collected, assumptions, and scaling calculations to estimate the concentrations and release rates is contained in the *Hull Coating Leachate ChAR*.

4.1.1 Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings

The discharge from this MPCD option group is the same as the baseline discharge. Information presented in Section 4.1 for the baseline discharge pertains to the discharge from this MPCD option group. Additional characterization and calculations were not necessary.

4.1.2 Foul-Release Coatings

As described in Section 3.2.2, the unique surface chemistry of foul-release coatings creates a surface to which fouling cannot easily adhere (NRL, 1997). The U.S. Environmental Protection Agency (EPA) has determined that foul-release coatings are exempt from reporting under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Public Law 95-396), because biocides are not released to control biofouling. The release of any other constituents that may be present in Intersleek 425 is expected to be negligible. Therefore, toxic or hazardous constituents were assumed not to be released to the environment. Discharge characterization data is not presented.

International Intersleek 425 is the only foul-release coating approved for use on Armed Forces vessels, and it is used as the basis for this analysis. International Intersleek has a service life of three years on vessels in the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group.

4.1.3 Advanced Antifouling Coatings

Advanced antifouling coatings can offer environmental benefits because the quantity of copper can be reduced or eliminated and non-persistent biocides can be incorporated. The USCG has approved one copper-free advanced antifouling coating for use on smaller, aluminum-hulled USCG vessels – *E Paint SN-1* (USCG, 2000). This coating contains the patented, non-metallic, biocide Sea-Nine211®. *E Paint SN-1* has a maximum service life of two years and is more durable and easier to maintain than foul-release coatings (USCG, 2000). Advanced antifouling coatings have failed to meet the minimum performance requirements in MIL-PRF-24647 and are not qualified for use on Navy vessels (Lawrence, 2003).

The advanced antifouling coatings MPCD option was analyzed on the basis that all vessels in this vessel group would be coated with *E Paint SN-1*. Table 4-2 presents the constituent information from the discharge of advanced antifouling coatings. The release rate of constituents from advanced antifouling coatings is not as dependent on the vessel movement as for ablative coatings. Therefore, only one release rate value is reported for each constituent. Information supplied from the E Paint Company was the major source of information for the discharge.

Table 4-2. Estimated Constituent Information for the Discharge from the Use of Advanced Antifouling Coatings on All Vessels in the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (µg/l)	Release Rate (µg/cm^2/day)	Constituent Mass Loading (lb/vessel group-year)	TPE (lb-equiv/yr)	BCC Identified
Sea-Nine211® (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one)	1.0[c]	1.8[a]	21,000	440,000	No
Total Zinc	10[c]	17[c]	200,000	14,000	Reduction

[a]Manufacturer information.
[b]Previous Navy Studies.
[c]Scaled from weight percentage or known release rate.

A complete description of the information collected, assumptions, and scaling calculations to estimate the concentrations and release rates is contained in the *Hull Coating Leachate ChAR*.

4.2 Feasibility Impact Analysis of the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

The feasibility analysis assessed the practicability and operational impact of the three MPCD options groups as well as the possible cost to implement each MPCD option. The choice of hull coating directly affects a vessel's ability to satisfy mission requirements as well as the normal drydocking and maintenance schedules for vessels. Costs were estimated to implement each MPCD option. All MPCD options are estimated to incur costs to modify the existing military specification, manuals, and contracts that determine which coating may be used on vessels. Additional costs were estimated for the increased maintenance and application of coatings resulting from the use of the MPCD options.

The MPCD option to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings results in additional costs due to the need to modify existing military specifications and manuals to incorporate the release rate standard. The currently used copper-containing coatings are the basis for this MPCD option and no additional impacts are estimated.

Foul-release coatings allow marine organisms to grow on the hull and rely on the flow of water over the hull or hull cleaning to remove any fouling that does not grow on the hull during periods of inactivity. Significant impacts on mission capabilities are assumed to result from the use of foul-release coatings due to the difference between operating cycles of Armed Forces vessels and commercial vessels for which the coatings have been proven effective. In addition, foul-release coatings have an estimated three-year service life on a USS NIMITZ Class vessel, resulting in an increased drydocking and coating application schedule as well as additional costs for the Armed Forces.

Commercially available advanced antifouling coatings are not as effective as copper-containing coatings at preventing hull fouling over extended periods. The advanced antifouling coating approved for use by the USCG fouls too quickly for Navy applications, does not satisfy the Navy performance requirements in MIL-PRF-24647, and can not be used on Navy vessels (Lawrence, 2003). Significant impacts on mission capabilities are expected to result from the use of the currently approved advanced antifouling coatings due to the limited effectiveness of the biocide. In addition, advance antifouling coatings would be expected to have a maximum two-year service life in the hypothetical case of application on a USS NIMITZ Class vessel resulting in an increased drydocking and coating application schedule as well as additional costs for the Armed Forces.

A summary of the feasibility impacts by vessel group and MPCD option is presented in Table 4-3.

Table 4-3. Feasibility Impact Summary of the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

MPCD Option	Analysis Factors				
	Mission Capabilities	**Drydock and Pierside Maintenance**	**Initial Costs ($K, in 1999 dollars)**	**12-Year Recurring Costs ($K, in 1999 dollars)**	**Annualized Total Ownership Costs ($K, in 1999 dollars)**
Establish Maximum Copper Standard	None	None	42	1,500	130
Foul-Release Coatings	Reduces speed, range, and mission availability	Significantly increases drydocking frequency and maintenance	48	7,000	580
Advanced Antifouling Coatings	Reduces speed, range, and mission availability due to greater fouling.	Significantly increases drydocking frequency and maintenance	73	9,300	770

A complete description of the assumptions, impacts, and costs is contained in the *Hull Coating Leachate FIAR*.

4.3 Environmental Effects Analysis of the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

The environmental effects were analyzed for the baseline discharge and discharges resulting from each MPCD option. Copper-containing coatings are the basis for the baseline discharge.

For purposes of this analysis, the MPCD option to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings is not expected to alter the baseline discharge, but is anticipated to limit use of high copper release coatings in the future.

The foul-release coatings MPCD does not result in any biocidal constituents being released to the surrounding water as a means of controlling fouling. However, the inability of these coatings to deter fouling from adhering to the hull may increase the likelihood of transfer and release of nonindigenous species. The need to reapply foul-release coatings more frequently than copper-containing coatings also results in additional VOCs emissions and solid waste generation. The impact of potential nonindigenous species release and other potential impacts from foul-release coatings cannot be quantified with existing data, but may be significant depending on vessel operation.

The advanced antifouling coatings MPCD results in a decrease in the number of BCCs identified and exceedences of water quality criteria over the baseline copper-containing coatings. The total quantity discharged is estimated to be greater, but the advanced antifouling coating constituents have few known environmental impacts. Additionally, the active ingredient in the USCG-approved *E Paint SN-1* is not persistent in the environment. The impact of potential nonindigenous species release and other potential impacts from advanced antifouling coatings cannot be quantified with existing data, but may be significant depending on vessel operation.

A summary of the environmental effects of the Hull Coating Leachate discharge from the various MPCD options and baseline for this vessel group were evaluated and are summarized in Table 4-4.

Table 4-4. Summary of EEA for the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

	Baseline Discharge	**Establish Maximum Copper Standard**	**Foul-Release Coatings**	**Advanced Antifouling Coatings**
Number of Constituents Exceeding Strictest WQC	1	1	0	0
Total Number of Exceeded WQC	Copper Ablative Coatings: Acute: 19 Chronic: 16 Vinyl Antifouling Coatings: Acute: 20 Chronic: 17	Copper Ablative Coatings: Acute: 19 Chronic: 16 Vinyl Antifouling Coatings: Acute: 20 Chronic: 17	0	0
Number of Exceeded Narrative Categories	0	0	0	0
Discharge Hazard Index at 35 m Edge of Mixing Zone	Copper Ablative Coatings: 7.0×10^{-3} Vinyl Antifouling Coatings: 9.8×10^{-3}	Copper Ablative Coatings: 7.0×10^{-3} Vinyl Antifouling Coatings: 9.8×10^{-3}	0	5.7×10^{-3}
Potential Nonindigenous Species Release	Baseline	Baseline	Increased from baseline	Increased from baseline
Number of BCCs Identified	2	2	0	1
Discharge Mass Loading of All Constituents (lb/yr)	170,000	170,000	0	220,000
Discharge TPE (lb-equiv/yr)	220,000	220,000	0	450,000
Other Environmental Impacts -- VOC emissions, solid waste generated	Baseline	Baseline	Increased from baseline	Increased from baseline

In summary, foul-release coatings have a discharge TPE of zero, are unlikely to result in any WQC exceedences, and contain no identified BCCs. Therefore, the use of foul-release coatings would result in the least environmental impact. While advanced antifouling coatings have a discharge TPE of 450, 000 lb-equiv/yr, the biocide is non-persistent. Additionally, advanced antifouling coatings are unlikely to result in any WQC exceedences and contain one identified BCC. The MPCD Option to Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings has a discharge TPE of 220,000 lb-equiv/yr that is produced by persistent biocides, results in copper concentrations that are most likely to exceed WQC, and contains two BCCs. None of the MPCD options is expected to result in acute toxicity 35 m from the hull.

For the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, MPCD ranking by overall environmental effect is:

1. Foul-Release Coatings
2. Advanced Antifouling Coatings
3. Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings

Additional information on the environmental effects analysis is included in the *Hull Coating Leachate EEAR.*

4.4 Cost-Effectiveness Analysis of the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

As a means of comparing the various MPCD options, the incremental pounds removed for each MPCD option is compared to the baseline discharge. These pounds are then compared with the incremental cost of each MPCD option. Finally, a cost per pound removed is calculated and used to compare the MPCD option cost-effectiveness. The comparison results are presented in Table 4-5. As shown below, the use of foul-release coatings would remove 220,000 TPE discharged from baseline at an incremental cost of $460,000,000 per year resulting in an incremental cost of $2,100 per lb-equiv removed. The use of advanced antifouling coatings would increase the total quantity discharged from baseline by 230,000 pounds, as noted by the “-230,000,” at an incremental cost of $640,000,000 per year.

Table 4-5. Cost-Effectiveness Analysis of MPCD Options for the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

	Establish Maximum Copper Standard	**Foul-Release Coatings**	**Advanced Antifouling Coatings**
Incremental TPE Removed from Baseline (lb-equiv removed/yr)	0	220,000	-230,000
Incremental Annualized Cost from Baseline ($K, in 1999 dollars)	3.5	460,000	640,000
Incremental Cost per TPE Removed ($/lb-equiv removed)	N/A	2,100	N/A

N/A = The incremental cost per pound removed is not applicable when the incremental TPE removed increases and the incremental annualized cost decreases or when the incremental TPE removed is zero.

5 Summary of Impacts – Flexible (Non-Aluminum) Hulls Vessel Group

The Flexible (Non-Aluminum) Hulls vessel group includes 59 vessels. This accounts for 1.9% of the vessels and 8.1% of the wetted hull surface area that produce Hull Coating Leachate discharge. All of the vessels in this group are Navy vessels. The USS LOS ANGELES (SSN 688) Class has been chosen as the representative vessel for this group.

5.1 Characterization of Flexible (Non-Aluminum) Hulls Vessel Group

Vessels with flexible hulls use the same copper ablative coatings (i.e., International Interspeed 640 (BRA640) and Ameron Coatings ABC #3) as the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group. Although used on some vessels to achieve a 12-year docking periodicity, copper ablative antifouling coatings typically have a three-year service life when applied to a flexible hulled vessel. The difference in estimated service life between vessel groups is due to the thickness of the copper ablative coating and the observed tendency of ablative coatings to crack when applied over the flexible substrate. The reduced service life of the ablative coating does not interfere with operations, because submarines are docked more frequently than surface ships. Navy research continues to search for coatings that may be more suitable to the flexible exterior of these vessels.

The baseline discharge from this vessel groups is a result of constituents leaching from copper ablative coatings. A combination of information received from coating manufacturers and government studies are the basis for all estimations and calculations. Constituent concentrations at 1 cm from the hull and release information for the baseline discharge are presented in Table 5-1. As discussed in the *Hull Coating Leachate ChAR*, any VOCs present in coatings were assumed to dissipate during the coating drying/curing process and are not included in the list of constituents discharged from the various coatings characterized.

Table 5-1. Constituent Information for the Baseline Discharge of the Flexible (Non-Aluminum) Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (µg/l)	Release Rate ($\mu g/cm^2/day$)		Constituent Mass Loading (lb/vessel group-year)	TPE (lb-equiv/yr)	BCC Identified
		Static	Dynamic			
Total Copper	5.3[b]	8.9[b]	17.0[b]	7,600	14,000	Reduction
Total Iron	0.26[c]	0.44[c]	0.84[c]	380		No
N-ethyltoluenesulfonamide	0.31[c]	0.52[c]	1.2[c]			No
Plasticizer	0.28[c]	0.47[c]	1.1[c]			No
Polyamide resin	0.28[c]	0.47[c]	1.1[c]			No
Rosin	1.0[c]	1.6[c]	3.8[c]			No
Total Zinc	2.1[c]	3.6[b]	6.7[b]	3,100	210	Reduction

[a]Manufacturer information.
[b]Previous Navy Studies.
[c]Scaled from weight percentage or known release rate.

A complete description of the information collected, assumptions made, and calculations performed to estimate the concentrations and release rates is contained in the *Hull Coating Leachate ChAR.*

5.1.1 Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings

The discharge from this MPCD option group is the same as the baseline discharge. Information presented in Section 4.1 for the baseline discharge pertains to the discharge from this MPCD option group. Additional characterization and calculations were not necessary.

5.1.2 Foul-Release Coatings

As discussed in the *Hull Coating Leachate FIAR*, foul-release coatings were tested on an Australian submarine in the 1990s resulting in excessive hull fouling (DSTO, 1995; Holmdahl, 2000). Before foul-release coatings can be applied to U.S. Navy submarines, performance validation testing would be required on an existing Navy nuclear submarine to ensure that its mission would not be affected and that damage from fouling would not occur to critical shipboard systems. Validation testing has not been done. Therefore, the foul-release coatings MPCD option is not feasible for this vessel group, and no characterization data was developed.

5.1.3 Advanced Antifouling Coatings

The advanced antifouling coating, *E Paint SN-1*, has not met the minimum performance requirements of military specification MIL-PRF-246-47 and is not authorized for use on Navy vessels (Lawrence, 2003). Therefore, the Advanced Antifouling Coatings MPCD option is not feasible for this vessel group, and no characterization data was developed.

5.2 Feasibility Impact Analysis of Flexible (Non-Aluminum) Hulls Vessel Group

The feasibility analysis assessed the practicability and operational impact of the three MPCD options groups as well as the cost to implement each MPCD option. The choice of hull coating directly affects a vessels ability to satisfy mission requirements as well as the normal drydocking and maintenance schedules for vessels. Costs to implement each MPCD option were estimated. Costs were estimated for all MPCD options to modify existing military specification, manuals, and contracts that determine which coating may be used on vessels. Also, costs connected with coating maintenance and replacement were included.

The MPCD option to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings was the only option determined to be feasible. Incremental costs for this MPCD are limited to those for establishing the initial release rate limit and those to modify existing military specifications and manuals to incorporate the release rate standard. A numerical maximum allowable copper release rate standard would be based on the results of ongoing Navy testing using the American Society for Testing and Materials (ASTM) D 6442, *Standard Test Method for Copper Release Rates of Antifouling Coating Systems in Seawater*. A summary of the feasibility impacts by vessel group and MPCD option is presented in Table 5-2.

Table 5-2. Feasibility Impact Summary of the Flexible (Non-Aluminum) Hulls Vessel Group

MPCD Option	Analysis Factors				
	Mission Capabilities	**Drydock and Pierside Maintenance**	**Initial Costs ($K, in 1999 dollars)**	**12-year Recurring Costs ($K, in 1999 dollars)**	**Annualized Total Ownership Costs ($K, in 1999 dollars)**
Establish Maximum Copper Standard	None	None	36	310,000	26,000
Foul-Release Coatings	MPCD option is not feasible.				
Advanced Antifouling Coatings	MPCD option is not feasible.				

A complete description of the impacts identified, costs, and assumptions made is contained in the *Hull Coating Leachate FIAR.*

5.3 Environmental Effects Analysis of Flexible (Non-Aluminum) Hulls Vessel Group

The environmental effects were analyzed for the baseline discharge and discharges resulting from each MPCD option. Copper-containing coatings are the basis for the baseline discharge.

For purposes of this analysis, the MPCD option to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings is not expected to alter the baseline discharge, but is anticipated to limit the use of high copper release coatings in the future. The foul-release coatings and advanced antifouling coatings MPCD options are not feasible; therefore, environmental effects were not analyzed. A summary of the environmental effects of the Hull Coating Leachate discharge for the various MPCD options and baseline discharge for this vessel group were evaluated and are summarized in Table 5-3.

Table 5-3. Summary of EEA for the Flexible (Non-Aluminum) Hulls Vessel Group

	Baseline Discharge	**Establish Maximum Copper Standard**	**Foul-Release Coatings**	**Advanced Antifouling Coatings**
Number of Constituents Exceeding Strictest WQC	1	1	NF	NF
Total Number of Exceeded WQC	Acute: 19 Chronic: 16	Acute: 19 Chronic: 16		
Number of Exceeded Narrative Categories	0	0		
Discharge Hazard Index at 35 m Edge of Mixing Zone	7.0×10^{-3}	7.0×10^{-3}		
Potential Nonindigenous Species Release	Low	Low		
Number of BCCs Identified	2	2		
Discharge Mass Loading of All Constituents (lb/yr)	11,000	11,000		
Discharge TPE (lb-equiv/yr)	14,000	14,000		
Other Environmental Impacts – VOC emissions, solid waste generated	Not quantified	Same as baseline		

NF = MPCD Option was determined to not be feasible.

In summary, the option to Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings is the only feasible MPCD option for this vessel group. Additional information on the environmental effects analysis is included in the *Hull Coating Leachate EEAR*.

5.4 Cost-Effectiveness Analysis of Flexible (Non-Aluminum) Hulls Vessel Group

As a means of comparing the various MPCD options, the incremental pounds removed for each MPCD option is compared to the baseline discharge. These pounds are then compared with the incremental cost of each MPCD option. Finally, a cost per pound removed is calculated and used to compare the MPCD option cost-effectiveness. The comparison results are presented in Table 5-4. As shown below, the MPCD option to Establish a Maximum Allowable Copper

Release Rate for Antifouling Coatings would result in no change in the total pounds discharged from baseline at an incremental cost of $3,000 per year.

Table 5-4. Cost-Effectiveness Analysis of MPCD Options for the Flexible (Non-Aluminum) Hulls Vessel Group

	Establish Maximum Copper Standard	Foul-Release Coatings	Advanced Antifouling Coatings
Incremental TPE Removed from Baseline (lb-equiv removed/yr)	0		
Incremental Annualized Cost from Baseline ($K, in 1999 dollars)	3	NF	NF
Incremental Cost per TPE Removed ($/lb-equiv removed)	N/A		

N/A = The incremental cost per pound removed is not applicable when the incremental TPE removed is zero.
NF = MPCD Option was determined to not be feasible.

6 Summary of Impact – Aluminum Hulls Vessel Group

The Aluminum Hulls vessel group includes 403 vessels and accounts for 13% of vessels of the Hull Coating Leachate discharge; but only 0.46% of the wetted surface area because they have much smaller hull area, on average, than vessels in the other vessel groups. The USCG 47-foot Motor Lifeboat (MLB 47) is the representative vessel for this vessel group.

6.1 Characterization of Aluminum Hulls Vessel Group

For the Aluminum Hulls vessel group, foul-release or advanced antifouling coatings are currently used. The decision regarding which coating type to use is made by local maintenance staff based on issues such as the local rate of fouling growth, the prevalence of ice in a region, and the availability of contractors who are qualified to apply the foul-release coatings. Approximately 90% of these vessels are coated with advanced antifouling coatings and 10% are coated with foul-release coatings (Dust, 2003a). Thus, the baseline discharge from the Aluminum Hulls vessel group results from the use of advanced antifouling and foul-release coatings. *E Paint SN-1* is the advanced antifouling coating used as the basis for these analyses and has a maximum two-year service life. Intersleek 425 is the foul-release coating used as the basis for these analyses with a three-year service life.

As described in Section 3.2.2, foul-release coatings do not release biocides to control biofouling. The release of any other constituents that may be present in Intersleek 425 is expected to be negligible. Toxic or hazardous constituents were assumed not to be released to the environment. Therefore, discharge characterization data is not presented. Information on the constituents released from advanced antifouling coatings are presented in Table 6-1. As presented in the *Hull Coating Leachate ChAR*, any VOCs present in coatings were assumed to dissipate during the drying/coating curing process and are not included in the list of constituents discharged from the coatings characterized.

Table 6-1. Constituent Information for the Baseline Discharge for the Aluminum Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (μg/l)	Release Rate ($\mu g/cm^2/day$)	Constituent Mass Loading (lb/vessel group-year)	TPE (lb-equiv/yr)	BCC Identified
Sea-Nine211® (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one)	1.0 [c]	1.8 [a]	140	2,900	No
Total Zinc	10 [c]	17 [c]	1,300	84	Reduction

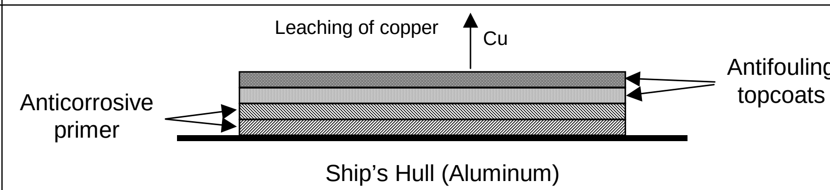
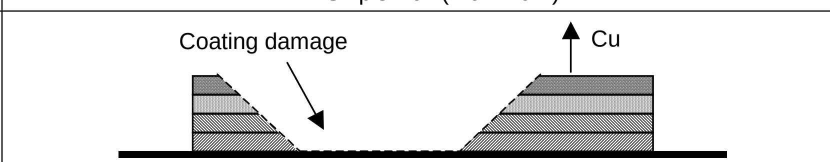
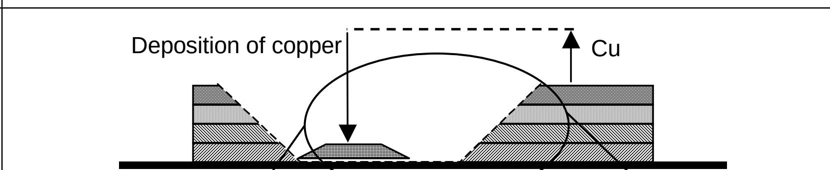
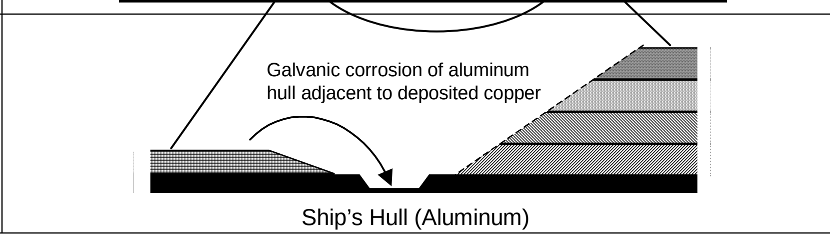
[a]Manufacturer information; [b]Previous Navy Studies; [c]Scaled from weight percentage or known release rate.

A complete description of the information collected, assumptions made, and calculations performed, to estimate the concentrations and release rates is contained in the *Hull Coating Leachate ChAR.*

6.1.1 Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings

The use of copper-containing coatings on aluminum hulls is not approved by the current specifications for underwater hull antifouling coatings due to the possibility of deposition corrosion (Navy, 2001a; USCG, 2001). Deposition corrosion occurs when copper from the antifouling coating plates out onto an area of bare aluminum substrate, leading to galvanic corrosion of the hull as depicted in Figure 6-1 (Jones, 1992; Lamtec, 2001). Therefore, this MPCD option is not feasible for the aluminum hulls vessel group and no further analysis was conducted.

Figure 6-1. Steps Involved in Deposition Corrosion

Step	Description	Schematic
1	Application of typical copper-containing antifouling coating to an aluminum hull; copper leaches into the surrounding seawater	
2	Mechanical damage occurs to the coating system, exposing bare aluminum	
3	Copper is deposited (plated) as metallic copper on the bare aluminum	
4	Metallic copper causes galvanic corrosion of adjacent areas of bare aluminum	

6.1.2 Foul-Release Coatings

As previously stated, the unique surface chemistry of foul-release coatings creates a surface to which fouling cannot easily adhere (NRL, 1997). The U.S. Environmental Protection Agency (EPA) has determined that foul-release coatings are exempt from reporting under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Public Law 95-396), because biocides are not released to control biofouling. The release of any other constituents that may be present in Intersleek 425 is expected to be negligible. Therefore, toxic or hazardous constituents were assumed not to be released to the environment. Discharge characterization data is not presented.

International Intersleek 425 is the only foul-release coating approved for use on Armed Forces vessels and is used as the basis for all analyses. International Intersleek has a service life of three years on vessels in the Aluminum Hulls vessel group.

6.1.3 Advanced Antifouling Coatings

As described in Section 4.1.3, advanced antifouling coatings have many environmental advantages, because the coating formulations do not contain tributyltin (TBT), the quantity of copper can be reduced or eliminated, and new non-persistent biocides can be incorporated. Some advanced antifouling coatings contain copper and a non-metallic co-biocide while others are based on non-metallic biocides.

The USCG has approved one copper-free advanced antifouling coating for use on smaller, aluminum-hulled USCG vessels – *E Paint SN-1* (USCG, 2000). This coating contains the patented biocide Sea-Nine211®. *E Paint SN-1* has a maximum service life of two years and is more durable and easier to maintain than foul-release coatings (USCG, 2000). Advanced antifouling coatings have failed to meet the minimum performance requirements in MIL-PRF-24647 and are not qualified for use on Navy vessels (Lawrence, 2003). Table 6-2 presents the constituent information from the discharge of advanced antifouling coatings to all vessels in the Aluminum Hulls vessel group. Information supplied from the E Paint Company is the major source of information for the discharge.

Table 6-2. Estimated Constituent Information for the Discharge from the Use of Advanced Antifouling Coatings on All Vessels of the Aluminum Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (µg/l)	Release Rate (µg/cm^2/day)	Constituent Mass Loading (lb/vessel group-year)	TPE (lb-equiv/yr)	BCC Identified
Sea-Nine211® (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one)	1.0 [c]	1.8 [a]	150	3,200	No
Total Zinc	10 [c]	17 [c]	1,400	93	Reduction

[a]Manufacturer information.
[b]Previous Navy Studies.
[c]Scaled from weight percentage or known release rate.

A complete description of the information collected, assumptions made, and calculations performed to estimate the concentrations and release rates is contained in the *Hull Coating Leachate ChAR.*

6.2 Feasibility Impact Analysis of Aluminum Hulls Vessel Group

The feasibility analysis assessed the practicability and operational impact of the three MPCD options groups as well as the possible cost to implement each MPCD option. The choice of hull coating directly affects a vessel's ability to satisfy mission requirements as well as the normal drydocking and maintenance schedules for vessels. Costs were estimated to implement each MPCD option. MPCD options are estimated to incur costs to modify the existing military specification, manuals, and contracts that determine which coating may be used on vessels. Additional costs were estimated for the increased maintenance and application of coatings resulting from the use of the MPCD options.

The MPCD option to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings is not feasible for the Aluminum Hulls vessel group due to the possibility of deposition corrosion.

Foul-release coatings are currently used on 10% of vessels in the Aluminum Hulls vessel group. Foul-release coatings allow marine organisms to grow on the hull and rely on the flow of water across the hull or hull cleaning to remove any fouling that does not grow on the hull during periods of inactivity.

Advanced antifouling coatings are used on 90% of the vessels in the Aluminum Hulls vessel group. The use of advanced antifouling coatings would not have significant impacts on mission capabilities or costs, but the decision to use alternate coatings is important in the ability of maintenance staff to properly deal with local issues (e.g., applicator qualifications, hull fouling rate).

A summary of the feasibility impacts of using each MPCD option on all vessels in the Aluminum Hulls vessel group is presented in Table 6-3.

Table 6-3. Feasibility Impact Summary for the Aluminum Hulls Vessel Group

MPCD Option	Analysis Factors				
	Mission Capabilities	**Drydock and Pierside Maintenance**	**Initial Costs** ($K, in 1999 dollars)	**12-year Recurring Costs** ($K, in 1999 dollars)	**Annualized Total Ownership Costs** ($K, in 1999 dollars)
Baseline Discharge (Foul-Release and Advanced Antifouling Coatings)	None	None	0	21,000	1,800
Establish Maximum Copper Standard	MPCD option is not feasible				
Foul-Release Coatings	Reduces speed, range, and mission availability	Increased pierside maintenance	12	25,000	2,100
Advanced Antifouling Coatings	None	None	55	21,000	1,800

A complete description of the impacts identified, costs, and assumptions is contained in the *Hull Coating Leachate FIAR*.

6.3 Environmental Effects Analysis of Aluminum Hulls Vessel Group

The environmental effects were analyzed for the baseline discharge and discharges resulting from each MPCD option. The baseline discharge results from the use of advanced antifouling and foul-release coatings. Approximately 90% of the aluminum vessels are coated with advanced antifouling coatings and 10% are coated with foul-release coatings (Dust, 2003a). The environmental effects of the Hull Coating Leachate discharge for the various MPCD options and baseline discharge for Aluminum Hulls vessel group were evaluated and are summarized in Table 6-4.

Table 6-4. Summary of EEA for the Aluminum Hulls Vessel Group

	Baseline Discharge	Establish Maximum Copper Standard	Foul-Release Coatings	Advanced Antifouling Coatings
Number of Constituents Exceeding Strictest WQC	0		0	0
Total Number of Exceeded WQC	0		0	0
Number of Exceeded Narrative Categories	0		0	0
Discharge Hazard Index at 35 m Edge of Mixing Zone	5.7×10^{-3}		0	5.7×10^{-3}
Potential Nonindigenous Species Release	Baseline		Increased from Baseline	Decreased from baseline
Number of BCCs Identified	1	NF	0	1
Discharge Mass Loading of All Constituents (lb/yr)	1,400		0	1,500
Discharge TPE (lb-equiv/yr)	3,000		0	3,300
Other Environmental Impacts – VOC emissions, solid waste generated	Baseline		- Reduced VOC emissions from baseline. - Increased solid waste generated from baseline.	- Increased VOC emissions from baseline. - Reduced solid waste generated from baseline.

NF = MPCD Option was determined to not be feasible.

For the Aluminum Hulls vessel group, the following is the MPCD ranking by overall environmental effect (e.g., "1. Foul-release Coatings" has the least environmental effect):

1. Foul-release Coatings
2. Baseline Discharge
3. Advanced Antifouling Coatings

In summary, foul-release coatings have a discharge TPE of zero, are unlikely to result in any WQC exceedences, and contain no identified BCCs. Therefore, the use of foul-release coatings would result in the least environmental impact. Advanced antifouling coatings have a discharge TPE of 3,300 lb-equiv/yr, and the primary biocide is non-persistent. Additionally, advanced antifouling coatings are unlikely to result in any WQC exceedences and contain one identified BCC. The baseline discharge is a combined use of the foul-release and advance antifouling coatings MPCD options, and therefore, is ranked between the two. None of the MPCD options is expected to result in acute toxicity 35 m from the hull.

6.4 Cost-Effectiveness Analysis of Aluminum Hulls Vessel Group

As a means of comparing the various MPCD options, the incremental pounds removed for each MPCD option is compared to the baseline discharge. These pounds removed are then compared with the incremental cost of each MPCD option. Finally, a cost-per-pound removed is calculated and used to compare the MPCD option cost-effectiveness. The comparison results are presented in Table 6-5. As shown below, the use of foul-release coatings would remove 3,000 lb-equiv/yr from baseline at an incremental cost of $300,000 per year resulting in an incremental cost of $100 per pound removed. The use of advanced antifouling coatings would increase the total quantity discharged by 300 lb-equiv/yr, as noted by the "-300," and is estimated to decrease the cost of coating from the baseline by $29,000 on an annual basis, as noted by the "-29." For the use of advanced antifouling coatings, the incremental cost per pound removed is not an applicable calculation when the incremental pounds removed increases and the incremental annualized cost decreases, as noted by the "N/A."

Table 6-5. Cost-Effectiveness Analysis of MPCD Options for the Aluminum Hulls Vessel Group

	Establish Maximum Copper Standard	**Foul-Release Coatings**	**Advanced Antifouling Coatings**
Incremental TPE Removed from Baseline (lb-equiv removed/yr)	NF	3,000	-300
Incremental Annualized Cost from Baseline ($K, in 1999 dollars)	NF	300	-29
Incremental Cost per TPE Removed ($/lb-equiv removed)	NF	0.10	N/A

N/A = The incremental cost per pound removed is not applicable when the incremental pounds removed increases and the incremental annualized cost decreases.

NF = The MPCD Option is not feasible for this vessel group.

7 Overall Summary

As described in Section 1.1, Hull Coating Leachate is defined as "constituents that leach, dissolve, ablate, or erode from the paint on the hull into the surrounding seawater." For the purpose of the UNDS analyses, only vessels with coatings that control fouling by marine organisms are included (i.e., antifouling and foul-release coatings). Vessels without coatings or with epoxy or urethane anticorrosive coatings are not included in the analyses. DoD has estimated that 3,104 Armed Forces vessels have antifouling coatings and contribute to the Hull Coating Leachate discharge worldwide.

The following three MPCD options passed the MPCD screening process and were examined in the environmental effects and feasibility impact analyses:

- Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings,
- Foul-Release Coatings, and
- Advanced Antifouling Coatings.

Most Armed Forces vessels use copper-containing coatings. For the purposes of this analysis, the MPCD option to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings is anticipated to result in no immediate change to the release of constituents; however, over time, establishment of a maximum copper release rate may result in a reduction of environmental effects.

All vessels that produce the Hull Coating Leachate discharge were divided into three vessel groups to facilitate the environmental effects and feasibility impact analyses. The category with the largest wetted-hull surface area is the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, which includes most Armed Forces vessels. The second largest category is the Flexible Hulls vessel group, which consists of vessels that have hulls covered with flexible elastomeric materials. The third largest category is the Aluminum Hulls vessel group, which includes numerous classes of smaller vessels (e.g., 20-foot utility boats, 47-foot motor lifeboats, etc.) used by the Armed Forces.

The environmental effects, costs, and efficacy of the three MPCD options described above were analyzed for each of the three vessel groupings and the following summarizes these results:

- For the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, the MPCD option to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings was found not to have any impact on vessel operation and is anticipated to limit use of high copper release coatings in the future. The foul-release Coatings MPCD option showed that reductions in the copper discharge from the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group was possible at an estimated cost of $2,100 per toxic pound equivalent removed, but was considered to have significant feasibility impacts due to the limited service-life of the coating, the increased costs associated with hull cleaning, and potential adverse impact on military specific operational requirements. The Advanced Coatings MPCD option analysis also showed a reduction in the number of BCCs identified and quantity of copper discharge from the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, but feasibility impacts similar to those described for foul-release coatings were identified.

- For the Flexible Hulls vessel group, the MPCD option to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings was found not to have any impacts on vessel operation. The foul-release coatings MPCD option was not analyzed for use on the Flexible Hulls vessel group, because performance validation testing would be required on an existing Navy nuclear submarine to ensure that damage would not occur to critical shipboard systems. Validation testing has not been done. Advanced antifouling coatings were also not analyzed for use on the Flexible Hulls vessel group, because advanced antifouling coatings have not been qualified to any Navy specification and all vessels with flexible hulls are operated by the Navy.

- For the Aluminum Hulls vessel group, advanced antifouling and foul-release coatings are currently used. The MPCD option to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings was not applicable to the Aluminum Hulls vessel group and as such was not analyzed. The foul-release coatings MPCD option resulted in environmental improvements, but potential adverse impacts on mission capabilities and maintenance activities were identified. The advanced antifouling coatings MPCD resulted in no environmental improvement.

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APPENDIX A
VESSEL GROUPING

Table A-1. Vessels of the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
AC 1	0	2	996
AE 26	540	1	54,240
AFDL 1	200	1	28,112
AFDM 3	622	2	95,290
AGF 11	548	1	46,594
AGOR 14	220	2	20,346
AGOR 23	243	3	41,880
AGOR 26	172	1	10,869
AGSS 555	152	1	9,130
ANB 63	63	1	792
ANB 64	64	3	2,451
AOE 1	770	4	383,016
AOE 6 (MSC)	730	1	94,141
AOE 6 (Navy)	730	3	282,423
AP 27	27	4	580
APL 17	261	3	55,107
APL 2	261	4	73,476
APL 41	261	2	36,738
APL 53	261	1	18,369
APL 61	360	2	75,600
APL 65	260	2	41,920
AR 40	40	1	318
AR 63	63	2	1,584
ARDM 4	492	2	95,290
ARS 50	240	4	53,196
AS 39	620	2	116,672
ASDV	135	3	7,971
BARGE 120	120	2	15,400
BARGE 130	130	6	33,000
BARGE 60	60	1	1,680
BARGE 68	68	6	14,208
BARGE 70	70	1	2,300
BARGE 84	84	2	6,496
BARGE 90	90	2	5,688
BARGE 99	99	2	8,004

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
BC	110	3	12,264
BC-7005	110	2	8,176
BD 115T	200	6	62,652
BG	120	4	26,856
BK	45	4	7,788
BU 45	45	4	1,612
BUSL 49	49	28	13,384
BW 22	22	1	97
BW 25	25	2	248
CC 38	38	1	287
CG 47	529	24	970,416
CT 60	60	1	718
CV 63	990	1	141,470
CV 67	990	1	145,350
CVN 65	1040	1	156,990
CVN 68	1040	10	1,595,000
DD 963	529	18	695898
DDG 51	446	51	1,705,593
DS 22	22	2	194
DW 50	50	8	3,984
FFG 7	408	33	755,766
FR 22	22	1	97
HH 30	30	1	179
HL 29	29	1	167
HL 34	34	3	690
HL 36	36	1	258
HS 24	24	22	2,530
HSAC	40	1	350
IX 310	192	1	11,698
IX 502	316	1	26,048
IX 508	135	1	3,557
IX 514	125	1	7,076
IX 516	303	1	44,562
IX 517	196	1	8,394
IX 520	260	1	19,538
IX 521	280	1	28,880
IX 522	256	1	26,528
IX 523	168	1	10,576
IX 524	256	1	23,840
IX 525	927	1	258,606
IX 527	110	1	5,792
IX 528	150	1	7,308
IX 529	118	1	12,124

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
IX 530	110	1	5,756
IX 531	102	1	4,110
J BOAT 27	27	8	1,160
J BOAT 46	46	1	421
LCC 19	580	1	51,250
LCM 6 (N)	56	16	15,840
LCM 8 (A)	74	38	60,914
LCM 8 (N) (MSC)	74	30	48,090
LCM 8 (N) (Navy)	74	46	73,738
LCPL 11	36	10	2,580
LCPL 36	36	81	20,898
LCU 1466	119	1	4,415
LCU 1610 (Army)	135	1	3,915
LCU 1610 (Navy)	135	36	140,940
LCU 2000	174	29	192,734
LHA 1	778	4	349,860
LHD 1	778	7	619,143
LHD 8	844	1	88,965
LPD 1	500	3	123,078
LPD 14	548	2	93,776
LPD 17	684	12	777,456
LPD 7	548	5	240,295
LSD 36	540	3	130,218
LSD 41	580	6	290,100
LSD 49	580	4	195,088
LST 1179	500	1	34,650
LSV	273	9	157,230
LT 100	107	1	6,105
LT 128	128	5	49,280
MC 27	27	1	145
MC 40	40	1	318
MCB 25	26	1	134
MCM 1	217	8	67,280
MCS 12	556	1	49,945
MHC 51	174	12	77,016
ML 35	35	1	243
ML 40	40	1	318
MLB 44	44	29	11,165
MM 25	25	3	372
MSB 26	26	21	2,814
MW 26 (MSC)	26	3	402

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
MW 26 (Navy)	26	18	2,412
NR 1	137	1	5,595
NS 111	125	1	2,813
NS 143	143	1	4,598
NS 180	180	2	15,004
NS 20	20	2	160
NS 21	21	2	176
NS 22	22	8	776
NS 23	23	1	105
NS 24	24	1	115
NS 25	25	4	496
NS 26	26	2	268
NS 27	27	2	290
NS 28	28	4	624
NS 30	30	1	179
NS 32	32	3	609
NS 33	33	1	216
NS 35	35	2	486
NS 36	36	2	516
NS 38	38	1	287
NS 39	39	2	604
NS 40	40	4	1,272
NS 41	41	2	668
NS 49	49	1	478
NS 53	53	1	560
NS 54	54	2	1,162
NS 55	55	1	603
NS 57	57	1	648
NS 95	95	1	1,477
PC 1	170	13	48,152
PE 10	33	2	432
PE 12	39	3	906
PE 22	22	2	194
PE 24	24	1	115
PE 26	26	14	1,876
PE 33	33	12	2,592
PE 40	40	19	6,142
PE 8	26	14	1,876
PR 40	40	3	954
PWB 19	19	1	72
PWB 21	21	7	616
PWB 22	22	1	97
PWB 23	23	1	105
PWB 27	27	3	435
PWB 32	33	1	216
Q-BOAT	65	1	843
QST 35	56	27	16,875
SB 10	10	2	20
SB 12	12	27	810
SB 14	14	19	760
SB 15	15	1	46

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
SB 16	16	28	1,456
SB 18	18	8	520
SB 22	22	17	1,649
SB 30	30	3	537
SB 40	40	1	318
SB 41	41	1	334
SB 44	44	8	3,080
SC 22	22	3	291
SC 27	27	3	435
SC 65	65	5	4,215
SKI 14	14	7	280
SRB 30	30	2	358
SSBN 726	560	18	1,252,800
ST 44	44	20	7,700
ST 900	59	12	15,024
T-AE 26	564	7	379,680
T-AFS 1	581	3	140,790
T-AFS 8	524	3	137,337
T-AG 195	247	1	59,126
T-AGM 23	564	1	47,791
T-AGOS 1	224	6	56,670
T-AGOS 19	232	4	53,360
T-AGOS 23	282	1	19,691
T-AGS 45	442	1	36,590
T-AGS 51	208	2	20,170
T-AGS 60	329	6	116,298
T-AH 19	894	2	247,724
T-AKR 287	947	8	893,200
T-AKR 295	907	4	428,112
T-AKR 300	950	7	830,158
T-AKR 310	950	8	955,168
T-AO 187	677	13	578,643
T-ARC 7	503	1	41,176
T-ATF 166	226	6	68,388
TC 27	27	1	145
TC 28	28	1	156
TC 42	42	1	351
TC 43	43	1	368
TC 49	49	1	478
TPSB 25	25	20	2,490
TR 100	100	3	5,862
TR 120	120	6	12,762
TR 21	21	1	88
TR 72	72	3	3,105

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
U 22	22	5	485
U 24	24	1	115
U 25	25	1	124
U 31	31	1	191
UB 10	33	3	648
UB 12	39	2	604
UB 15	49	37	17,686
UB 21	21	3	264
UB 22	22	86	8,342
UB 25	25	7	868
UB 27	27	6	870
UB 28	28	1	156
UB 32	32	1	203
UB 33	33	3	648
UB 40 (MSC)	40	1	318
UB 40 (Navy)	40	14	4,452
UB 50	50	24	11,952
UTL 17	17	1	58
UTL 18	18	4	260
UTL 19	19	1	72
UTL 20	20	1	80
UTL 21	21	8	604
UTL 22	22	6	582
UTL 23	23	15	1,675
UTL 24	24	5	575
UTL 25	25	5	620
UTL 26	26	1	134
UTL 27	27	5	725
UTL 28	28	1	156
UTM 27	27	4	580
UTM 30	30	2	358
WB 110	110	1	2,536
WB 135	135	3	7,671
WB 15	49	12	5,736
WB 180	180	1	7,534
WB 20	20	1	80
WB 24	24	29	3,335
WB 25	25	1	124
WB 26	26	1	134
WB 27	27	1	145
WB 28	28	1	156
WB 30	30	2	358
WB 31	31	1	191
WB 34	34	1	230
WB 35	35	10	2,430
WB 41	41	2	668
WB 45	45	5	2,015
WB 50	50	77	38,346
WB 56	56	1	625
WB 74	74	13	20,839

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
WH 12	12	1	30
WH 16	16	6	312
WHEC 378	379	12	208,068
WIX 180	180	1	6,751
WIX 295	295	1	12,264
WLB 180	180	5	33,755
WLB 225	225	16	165,712
WLI 100	100	1	2,432
WLI 65 303	65	1	1,037
WLI 65 400	65	2	2,284
WLIC 100	100	2	4,864
WLIC 160	160	4	20,452
WLIC 75	75	9	15,777
WLM 133	133	1	4,648
WLM 175	175	14	89,612
WLR 65	65	3	4,725
WLR 75	75	6	9,726
WMEC 210	210	16	111,200
WMEC 213	213	1	8,337
WMEC 230	230	1	8,621
WMEC 270	270	13	142,688
WMEC 282	282	1	14,191
WPB 110	110	49	106,379
WPB 82	83	2	2,486
WPB 87	87	50	75,700
WYTL 65	65	12	12,996
YC 1026	150	2	17,320
YC 1273	100	1	5,680
YC 1321	125	2	12,316
YC 1351	81	1	3,051
YC 1366	110	6	37,020
YC 1389	160	1	11,536
YC 1427	110	3	18,132
YC 1436	120	1	6,408
YC 1448	130	2	11,640
YC 1461	110	2	11,584
YC 1469	110	22	127,424
YC 1500	110	4	24,680
YC 1517	110	36	208,512
YC 1607	110	39	203,736
YC 161	110	1	5,540
YC 255	110	16	98,720
YC 688	110	7	31,766
YC 981	142	2	16,456
YCF 14	150	1	6,572
YCV 7	200	3	51,720

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
YD 113	140	5	76,300
YD 120	140	2	30,636
YD 150	198	1	14,876
YD 159	120	1	9,360
YD 210	142	3	31,908
YD 222	142	1	9,986
YD 223	140	4	50,960
YD 232	142	3	31,908
YD 243	140	1	11,036
YD 246	175	9	145,125
YD 247	175	5	75,625
YFN 1154	110	3	18,510
YFN 1172	110	3	13,260
YFN 1173	110	5	28,780
YFN 1196	110	8	46,336
YFN 1239	110	2	11,584
YFN 1254	110	14	86,380
YFN 1277	110	7	43,190
YFN 161	110	31	191,270
YFNB 2	260	6	108,144
YFNB 47	152	1	7,728
YFND 5	110	3	17,640
YFNX 15	110	1	5,468
YFNX 20	110	1	4,538
YFNX 22	110	1	7,214
YFNX 24	110	1	5,792
YFNX 30	110	1	5,180
YFNX 31	110	1	5,346
YFNX 35	153	1	8,025
YFNX 36	110	1	5,918
YFNX 39	110	1	5,918
YFNX 40	110	1	5,792
YFNX 42	110	1	6,170
YFNX 43	110	1	6,076
YFNX 44	127	1	6,713
YFU 71	125	1	7,076
YFU 91	115	1	5,525
YGN 80	124	3	22,560
YL 30	30	1	179
YLC 1	110	1	5,224
YLC 2	110	1	4,088
YMN 1	154	1	6,330
YNG 1	110	2	9,784
YOGN 106	165	5	51,210
YOGN 123	230	1	14,012
YOGN 8	165	2	17,950
YON 245	165	18	177,840

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
YON 307	184	11	119,020
YON 89	165	3	26,925
YOS 14	110	1	6,332
YOS 33	165	3	26,925
YOS 4	110	1	6,332
YP 654	81	2	2,102
YP 676	108	21	46,641
YPD 45	110	1	6,044
YR 24	150	4	30,528
YR 26	153	5	38,880
YR 83	111	1	4,176
YR 84	210	2	14,700
YR 92	110	1	4,320
YR 93	261	1	18,090
YR 94	261	1	18,090
YRB 25	110	1	4,892
YRB 29	124	1	7,688
YRB 30	261	2	36,180
YRB 31	150	2	15,264
YRB 32	153	2	15,264
YRB 33	150	2	15,264
YRBM 1	110	1	4,604
YRBM 20	261	1	18,090
YRBM 23	146	8	66,016
YRBM 31	146	16	132,032

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
YRBM 48	150	2	15,264
YRBM 49	150	2	15,264
YRBM 5	112	5	26,080
YRBM 50	150	2	18,304
YRBM 51	153	2	15,552
YRBM 52	150	2	15,264
YRBM 53	150	2	15,264
YRDH 1	153	2	7,611
YRDM 1	153	1	7,611
YRR 11	151	3	22,551
YRR 2	153	1	7,776
YRR 5	150	1	7,632
YSD 11	104	1	4,304
YSR 30	110	2	12,920
YTB 760	109	19	62,035
YTL 422	66	1	1,015
YTT 9	186	2	24,824
YWN 60	165	1	8,975

Table A-2. Vessels of the Flexible Hulls Vessel Group

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
MCM 1	217	1	8,410
SSN 21	353	3	139,200
SSN 688	360	51	1,922,700
SSN 774	377	4	153,200

Table A-3. Vessels of the Aluminum Hulls Vessel Group

Vessel Class	Length (ft)	No. of Vessels	Class Wetted Surface Area (ft^2)
ANB 55	58	18	12,078
ANB(X) 34	34	2	460
ANB(X) 38	38	1	287
ATB 41	41	3	1,002
BH 22	22	1	97
FB	65	1	843
IMARV 50	50	1	498
MLB 47	47	98	43,120
TANB 21 CI	21	16	1,408
TANB 21 SI IB	21	18	1,584
TANB 21 SI OB	21	3	264
TANB 23	23	1	105
TPSB 22	22	2	194
UTB 41	41	163	54,442
UTL 13	13	1	35
UTL 15	15	1	46
UTL 16	16	1	52
UTL 17	17	5	290
UTL 18	18	4	260
UTL 19	19	1	72
UTL 20	20	2	160
UTL 21	21	8	704
UTL 22	22	6	582
UTL 23	23	17	1,785
UTL 24	24	5	575
UTL 25	25	5	620
UTL 26	26	1	134
UTL 27	27	5	725
UTL 28	28	1	156
UTL 36	36	1	258
UTM 27	27	4	580
UTM 28	28	1	156
UTM 30	30	3	537

APPENDIX B
MASS LOADINGS

Table B-1. Freshwater Mass Loadings for the Baseline Discharge from the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft^2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
ANB 63	63	100%	792	235	110	6.7E+00	2.7E-01	2.2E+00
ANB 64	64	100%	1,634	235	110	1.4E+01	5.6E-01	4.6E+00
AR 63	63	100%	792	300	40	5.7E+00	2.3E-01	1.9E+00
BARGE 120	120	100%	15,400	146	205	1.6E+02	6.4E+00	5.2E+01
BARGE 130	130	50%	33,000	146	205	3.4E+02	1.4E+01	1.1E+02
BARGE 90	90	50%	5,688	146	205	5.8E+01	2.4E+00	1.9E+01
BARGE 99	99	50%	8,004	146	205	8.2E+01	3.3E+00	2.7E+01
BUSL 49	49	100%	2,868	146	205	2.9E+01	1.2E+00	9.6E+00
BW 25	25	50%	124	155	60	6.4E-01	2.6E-02	2.1E-01
HS 24	24	50%	115	55	300	1.3E+00	5.1E-02	4.1E-01
IX 310	192	100%	11,698	325	30	8.5E+01	3.5E+00	2.8E+01
IX 531	102	100%	4,110	205	150	3.8E+01	1.6E+00	1.3E+01
LCM 6 (N)	56	100%	1,980	305	60	1.6E+01	6.4E-01	5.2E+00
LCM 8 (N)	74	100%	9,618	295	60	7.5E+01	3.1E+00	2.5E+01
LCPL 36	36	100%	1,290	305	60	1.0E+01	4.2E-01	3.4E+00
LCU 1610	135	100%	3,915	265	40	2.6E+01	1.0E+00	8.4E+00
ML 35	35	100%	243	205	60	1.5E+00	6.0E-02	4.9E-01
MLB 44	44	100%	2,310	305	30	1.6E+01	6.5E-01	5.3E+00
MW 26	26	50%	536	205	60	3.3E+00	1.3E-01	1.1E+00
NS 20	20	50%	80	305	60	1.7E-01	7.1E-03	5.7E-02
NS 25	25	50%	248	305	60	2.0E+00	8.1E-02	6.6E-01
NS 28	28	50%	156	305	60	1.2E+00	5.1E-02	4.1E-01
NS 32	32	50%	203	305	60	1.6E+00	6.6E-02	5.4E-01
NS 35	35	50%	243	305	60	1.9E+00	7.9E-02	6.4E-01
NS 36	36	50%	258	305	60	2.1E+00	8.4E-02	6.8E-01
NS 39	39	50%	302	305	60	2.4E+00	9.8E-02	8.0E-01
PE 26	26	50%	268	305	60	2.1E+00	8.7E-02	7.1E-01
PE 33	33	50%	216	305	60	1.7E+00	7.0E-02	5.7E-01
PE 40	40	50%	318	305	60	2.5E+00	1.0E-01	8.4E-01
PWB 21	21	50%	440	155	200	3.2E+00	1.3E-01	1.0E+00
SKI 14	14	100%	280	15	100	1.0E+00	4.1E-02	3.3E-01
TPSB 25	25	50%	496	245	100	4.1E+00	1.7E-01	1.4E+00
TR 21	21	50%	88	150	65	2.1E-01	8.5E-03	6.8E-02
U 22	22	100%	194	150	65	4.6E-01	1.9E-02	1.5E-01
UB 21	21	50%	88	195	150	4.8E-01	2.0E-02	1.6E-01
UB 22	22	50%	485	195	150	2.6E+00	1.1E-01	8.6E-01
UB 40	40	100%	318	195	150	2.9E+00	1.2E-01	9.6E-01
UTL 18	18	50%	65	195	150	3.5E-01	1.4E-02	1.2E-01
UTL 20	20	50%	80	195	150	4.4E-01	1.8E-02	1.4E-01
UTL 21	21	50%	176	195	150	9.6E-01	3.9E-02	3.1E-01
UTL 22	22	50%	97	195	150	5.3E-01	2.2E-02	1.7E-01

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft^2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
UTL 23	23	50%	420	195	150	2.3E+00	9.3E-02	7.4E-01
UTL 24	24	50%	115	195	150	6.3E-01	2.6E-02	2.0E-01
UTL 25	25	50%	124	195	150	1.1E+00	4.6E-02	3.7E-01
UTM 27	27	50%	145	195	150	1.3E+00	5.4E-02	4.4E-01
UTM 30	30	50%	358	195	150	3.3E+00	1.3E-01	1.1E+00
WB 24	24	50%	115	195	150	6.3E-01	2.6E-02	2.0E-01
WB 50	50	100%	1,494	195	150	1.4E+01	5.6E-01	4.5E+00
WB 74	74	100%	1,603	195	150	1.5E+01	6.0E-01	4.8E+00
WLB 180	180	50%	13,502	135	100	8.4E+01	3.4E+00	2.7E+01
WLB 225	225	100%	20,714	135	100	1.3E+02	5.2E+00	4.2E+01
WLI 100	100	100%	2,432	146	205	2.5E+01	1.0E+00	8.1E+00
WLIC 100	100	100%	2,432	146	205	2.5E+01	1.0E+00	8.1E+00
WLIC 75	75	100%	1,753	146	205	1.8E+01	7.3E-01	5.9E+00
WLM 175	175	100%	6,408	123	200	6.2E+01	2.5E+00	2.0E+01
WLR 65	65	50%	4,725	140	205	4.8E+01	1.9E+00	1.6E+01
WLR 75	75	50%	9,726	140	205	9.8E+01	4.0E+00	3.2E+01
YC 1273	100	100%	5,680	295	60	4.4E+01	1.8E+00	1.5E+01
YC 1366	110	100%	6,170	295	60	4.8E+01	2.0E+00	1.6E+01
YC 981	142	100%	8,228	295	60	6.4E+01	2.6E+00	2.1E+01
YCF 14	150	100%	6,572	305	60	5.3E+01	2.1E+00	1.7E+01
YFNX 22	110	100%	7,214	295	60	5.6E+01	2.3E+00	1.9E+01

Table B-2. Saltwater Mass Loadings for the Baseline Discharge from the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
AC 1	50	100%	996	285	60	7.6E+00	3.1E-01	2.5E+00
AE 26	540	100%	54,240	245	20	2.9E+02	1.2E+01	9.7E+01
AFDL 1	200	100%	28,112	305	60	2.3E+02	9.1E+00	7.4E+01
AFDM 3	622	100%	95,290	305	60	7.6E+02	3.1E+01	2.5E+02
AGF 11	548	100%	46,594	183	4	1.7E+02	6.9E+00	5.6E+01
AGOR 14	220	100%	20,346	145	20	7.1E+01	2.9E+00	2.4E+01
AGOR 23	243	100%	41,880	145	20	1.5E+02	5.9E+00	4.8E+01
AGOR 26	172	100%	10,869	145	20	3.8E+01	1.5E+00	1.3E+01
AGSS 555	152	100%	9,130	305	60	7.3E+01	3.0E+00	2.4E+01
ANB 64	64	100%	817	235	100	6.6E+00	2.7E-01	2.2E+00
AOE 1	770	100%	383,016	114	2	8.6E+02	3.5E+01	2.9E+02
AOE 6 (MSC)	730	100%	94,141	186	4	3.5E+02	1.4E+01	1.2E+02
AOE 6 (Navy)	730	100%	282,423	186	4	1.0E+03	4.2E+01	3.5E+02
AP 27	27	50%	580	105	60	2.4E+00	9.9E-02	8.0E-01
APL 17	261	100%	55,107	355	0	3.7E+02	1.5E+01	1.2E+02
APL 2	261	100%	73,476	355	0	5.0E+02	2.0E+01	1.7E+02
APL 41	261	100%	36,738	355	0	2.5E+02	1.0E+01	8.3E+01
APL 53	261	100%	18,369	355	0	1.2E+02	5.1E+00	4.1E+01
APL 61	360	100%	75,600	355	0	5.1E+02	2.1E+01	1.7E+02

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
APL 65	260	100%	41,920	355	0	2.8E+02	1.2E+01	9.4E+01
AR 40	40	100%	318	300	10	1.9E+00	7.9E-02	6.4E-01
AR 63	63	100%	792	300	10	4.8E+00	2.0E-01	1.6E+00
ARDM 4	492	100%	95,290	305	60	7.6E+02	3.1E+01	2.5E+02
ARS 50	240	100%	53,196	156	60	2.7E+02	1.1E+01	9.0E+01
AS 39	620	100%	116,672	235	60	7.8E+02	3.2E+01	2.6E+02
ASDV	135	100%	7,971	295	60	6.2E+01	2.5E+00	2.1E+01
BARGE 60	60	100%	1,680	146	205	1.7E+01	7.0E-01	5.6E+00
BARGE 68	68	100%	14,208	146	205	1.5E+02	5.9E+00	4.8E+01
BARGE 70	70	100%	2,300	146	205	2.4E+01	9.6E-01	7.7E+00
BARGE 84	84	100%	6,496	146	205	6.6E+01	2.7E+00	2.2E+01
BC	110	100%	12,264	335	0	7.9E+01	3.2E+00	2.6E+01
BC-7005	110	100%	8,176	335	0	5.2E+01	2.1E+00	1.7E+01
BD 115T	200	100%	62,652	335	0	4.0E+02	1.6E+01	1.3E+02
BG	120	100%	26,856	335	0	1.7E+02	7.0E+00	5.7E+01
BK	45	100%	7,788	335	0	5.0E+01	2.0E+00	1.7E+01
BU 45	45	100%	1,612	205	150	1.5E+01	6.1E-01	4.9E+00
BUSL 49	49	100%	10,516	146	205	1.1E+02	4.4E+00	3.5E+01
BW 22	22	50%	97	155	60	2.1E-01	8.6E-03	6.9E-02
BW 25	25	50%	124	155	60	6.4E-01	2.6E-02	2.1E-01
CC 38	38	50%	287	255	60	2.0E+00	8.2E-02	6.7E-01
CG 47	529	100%	970,416	166	4	3.2E+03	1.3E+02	1.1E+03
CT 60	60	100%	718	285	60	5.5E+00	2.2E-01	1.8E+00
CV 63	990	100%	141,470	147	3	4.1E+02	1.7E+01	1.4E+02
CV 67	990	100%	145,350	147	3	4.2E+02	1.7E+01	1.4E+02
CVN 65	1040	100%	156,990	147	3	4.6E+02	1.9E+01	1.5E+02
CVN 68	1040	100%	1,595,000	147	3	4.7E+03	1.9E+02	1.5E+03
DD 963	529	100%	695,898	178	4	2.5E+03	1.0E+02	8.2E+02
DDG 51	446	100%	1,705,593	109	63	7.4E+03	3.0E+02	2.4E+03
DS 22	22	50%	194	295	60	4.2E-01	1.7E-02	1.4E-01
DW 50	50	100%	3,984	305	60	3.2E+01	1.3E+00	1.1E+01
FFG 7	408	100%	755,766	168	4	2.5E+03	1.0E+02	8.4E+02
FR 22	22	50%	97	225	40	1.4E-01	5.7E-03	4.6E-02
HH 30	30	50%	179	285	60	1.4E+00	5.5E-02	4.5E-01
HL 29	29	50%	167	225	60	1.1E+00	4.4E-02	3.6E-01
HL 34	34	50%	690	225	60	4.5E+00	1.8E-01	1.5E+00
HL 36	36	50%	258	225	60	1.7E+00	6.8E-02	5.5E-01
HS 24	24	50%	2,415	55	300	2.6E+01	1.1E+00	8.6E+00
HSAC	40	50%	350	196	52	2.0E+00	8.0E-02	6.5E-01
IX 502	316	100%	26,048	355	0	1.8E+02	7.2E+00	5.9E+01
IX 508	135	100%	3,557	315	30	2.5E+01	1.0E+00	8.4E+00
IX 514	125	100%	7,076	265	60	5.1E+01	2.1E+00	1.7E+01
IX 516	303	100%	44,562	315	30	3.2E+02	1.3E+01	1.0E+02
IX 517	196	100%	8,394	335	30	6.3E+01	2.6E+00	2.1E+01
IX 520	260	100%	19,538	355	0	1.3E+02	5.4E+00	4.4E+01
IX 521	280	100%	28,880	305	60	2.3E+02	9.4E+00	7.6E+01
IX 522	256	100%	26,528	305	60	2.1E+02	8.6E+00	7.0E+01
IX 523	168	100%	10,576	245	100	8.8E+01	3.6E+00	2.9E+01
IX 524	256	100%	23,840	305	60	1.9E+02	7.8E+00	6.3E+01
IX 525	927	100%	258,606	305	60	2.1E+03	8.4E+01	6.8E+02
IX 527	110	100%	5,792	335	0	3.7E+01	1.5E+00	1.2E+01

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
IX 528	150	100%	7,308	305	60	5.9E+01	2.4E+00	1.9E+01
IX 529	118	100%	12,124	335	30	9.1E+01	3.7E+00	3.0E+01
IX 530	110	100%	5,756	305	60	4.6E+01	1.9E+00	1.5E+01
J BOAT 27	27	100%	1,160	290	65	9.2E+00	3.7E-01	3.0E+00
J BOAT 46	46	100%	421	285	50	3.1E+00	1.2E-01	1.0E+00
LCC 19	580	100%	51,250	172	10	1.9E+02	7.6E+00	6.2E+01
LCM 6 (N)	56	100%	13,860	305	60	1.1E+02	4.5E+00	3.7E+01
LCM 8 (A)	74	100%	60,914	295	60	4.8E+02	1.9E+01	1.6E+02
LCM 8 (N) (MSC)	74	100%	48,090	295	60	3.8E+02	1.5E+01	1.2E+02
LCM 8 (N) (Navy)	74	100%	64,120	295	60	5.0E+02	2.0E+01	1.7E+02
LCPL 11	36	100%	2,580	305	60	2.1E+01	8.4E-01	6.8E+00
LCPL 36	36	100%	19,608	305	60	1.6E+02	6.4E+00	5.2E+01
LCU 1466	119	100%	4,415	275	40	3.0E+01	1.2E+00	9.8E+00
LCU 1610 (Army)	135	100%	3,915	265	40	2.6E+01	1.0E+00	8.4E+00
LCU 1610 (Navy)	135	100%	137,025	265	40	8.9E+02	3.6E+01	2.9E+02
LCU 2000	174	100%	192,734	265	30	1.2E+03	4.8E+01	3.9E+02
LHA 1	778	100%	349,860	166	10	1.2E+03	5.0E+01	4.1E+02
LHD 1	778	100%	619,143	180	10	2.4E+03	9.6E+01	7.8E+02
LHD 8	844	100%	88,965	180	10	3.4E+02	1.4E+01	1.1E+02
LPD 1	500	100%	123,078	172	10	4.5E+02	1.8E+01	1.5E+02
LPD 14	548	100%	93,776	172	10	3.4E+02	1.4E+01	1.1E+02
LPD 17	684	100%	777,456	172	10	2.8E+03	1.2E+02	9.4E+02
LPD 7	548	100%	240,295	172	10	8.8E+02	3.6E+01	2.9E+02
LSD 36	540	100%	130,218	216	4	5.6E+02	2.3E+01	1.8E+02
LSD 41	580	100%	290,100	170	5	1.0E+03	4.0E+01	3.3E+02
LSD 49	580	100%	195,088	190	54	1.1E+03	4.4E+01	3.6E+02
LST 1179	500	100%	34,650	178	4	1.2E+02	5.0E+00	4.1E+01
LSV	273	100%	157,230	120	30	5.3E+02	2.2E+01	1.8E+02
LT 100	107	100%	6,105	275	60	4.5E+01	1.8E+00	1.5E+01
LT 128	128	100%	49,280	215	60	3.1E+02	1.3E+01	1.0E+02
MC 27	27	50%	145	205	60	8.8E-01	3.6E-02	2.9E-01
MC 40	40	100%	318	205	60	1.9E+00	7.9E-02	6.4E-01
MCB 25	26	100%	134	135	200	1.3E+00	5.4E-02	4.3E-01
MCM 1	217	100%	67,280	233	9	3.2E+02	1.3E+01	1.1E+02
MCS 12	556	100%	49,945	86	3	8.8E+01	3.6E+00	2.9E+01
MHC 51	174	100%	77,016	242	123	7.0E+02	2.8E+01	2.3E+02
ML 40	40	100%	318	205	60	1.9E+00	7.9E-02	6.4E-01
MLB 44	44	100%	8,855	305	30	6.1E+01	2.5E+00	2.0E+01
MM 25	25	50%	372	85	60	1.4E+00	5.8E-02	4.6E-01
MSB 26	26	100%	2,814	305	30	1.9E+01	7.9E-01	6.4E+00
MW 26 (MSC)	26	50%	402	205	60	2.4E+00	1.0E-01	8.1E-01
MW 26 (Navy)	26	50%	1,876	205	60	1.1E+01	4.6E-01	3.8E+00
NR 1	137	100%	5,595	315	40	4.2E+01	1.7E+00	1.4E+01
NS 111	125	100%	2,813	285	60	2.1E+01	8.7E-01	7.1E+00
NS 143	143	100%	4,598	305	60	3.7E+01	1.5E+00	1.2E+01
NS 180	180	100%	15,004	305	60	1.2E+02	4.9E+00	4.0E+01
NS 20	20	50%	80	305	60	1.7E-01	7.1E-03	5.7E-02

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
NS 21	21	50%	176	305	60	3.8E-01	1.6E-02	1.2E-01
NS 22	22	50%	776	305	60	1.7E+00	6.9E-02	5.5E-01
NS 23	23	50%	105	305	60	2.3E-01	9.3E-03	7.4E-02
NS 24	24	50%	115	305	60	2.5E-01	1.0E-02	8.1E-02
NS 25	25	50%	248	305	60	2.0E+00	8.1E-02	6.6E-01
NS 26	26	50%	268	305	60	2.1E+00	8.7E-02	7.1E-01
NS 27	27	50%	290	305	60	2.3E+00	9.4E-02	7.7E-01
NS 28	28	50%	468	305	60	3.7E+00	1.5E-01	1.2E+00
NS 30	30	50%	179	5	60	4.1E-01	1.7E-02	1.3E-01
NS 32	32	50%	406	305	60	3.3E+00	1.3E-01	1.1E+00
NS 33	33	50%	216	305	60	1.7E+00	7.0E-02	5.7E-01
NS 35	35	50%	243	305	60	1.9E+00	7.9E-02	6.4E-01
NS 36	36	50%	258	305	60	2.1E+00	8.4E-02	6.8E-01
NS 38	38	50%	287	305	60	2.3E+00	9.3E-02	7.6E-01
NS 39	39	50%	302	305	60	2.4E+00	9.8E-02	8.0E-01
NS 40	40	100%	1,272	305	60	1.0E+01	4.1E-01	3.4E+00
NS 41	41	100%	668	305	60	5.3E+00	2.2E-01	1.8E+00
NS 49	49	100%	478	5	60	1.1E+00	4.4E-02	3.5E-01
NS 53	53	100%	560	305	60	4.5E+00	1.8E-01	1.5E+00
NS 54	54	100%	1,162	305	60	9.3E+00	3.8E-01	3.1E+00
NS 55	55	100%	603	305	60	4.8E+00	2.0E-01	1.6E+00
NS 57	57	100%	648	305	60	5.2E+00	2.1E-01	1.7E+00
NS 95	95	100%	1,477	295	60	1.2E+01	4.7E-01	3.8E+00
PC 1	170	100%	48,152	95	6	9.8E+01	4.0E+00	3.2E+01
PE 10	33	50%	432	305	60	3.5E+00	1.4E-01	1.1E+00
PE 12	39	50%	906	305	60	7.3E+00	2.9E-01	2.4E+00
PE 22	22	50%	194	215	100	7.0E-01	2.9E-02	2.3E-01
PE 24	24	50%	115	215	100	4.2E-01	1.7E-02	1.4E-01
PE 26	26	50%	1,608	305	60	1.3E+01	5.2E-01	4.2E+00
PE 33	33	50%	2,376	305	60	1.9E+01	7.7E-01	6.3E+00
PE 40	40	50%	5,724	305	60	4.6E+01	1.9E+00	1.5E+01
PE 8	26	50%	1,876	305	60	1.5E+01	6.1E-01	5.0E+00
PR 40	40	100%	954	305	60	7.6E+00	3.1E-01	2.5E+00
PWB 19	19	50%	72	155	200	5.2E-01	2.1E-02	1.7E-01
PWB 21	21	50%	176	155	200	1.3E+00	5.2E-02	4.2E-01
PWB 22	22	50%	97	155	200	7.0E-01	2.9E-02	2.3E-01
PWB 23	23	50%	105	155	200	7.6E-01	3.1E-02	2.5E-01
PWB 27	27	50%	435	155	200	4.4E+00	1.8E-01	1.5E+00
PWB 32	33	50%	216	155	200	2.2E+00	9.0E-02	7.2E-01
Q-BOAT	65	100%	843	275	60	6.3E+00	2.5E-01	2.1E+00
QST 35	56	100%	16,875	196	52	9.5E+01	3.9E+00	3.1E+01
SB 10	10	100%	20	65	100	7.3E-02	3.0E-03	2.4E-02
SB 12	12	100%	810	65	100	2.9E+00	1.2E-01	9.6E-01
SB 14	14	100%	760	65	100	2.8E+00	1.1E-01	9.0E-01
SB 15	15	100%	46	65	100	1.7E-01	6.8E-03	5.4E-02
SB 16	16	100%	1,456	65	100	5.3E+00	2.2E-01	1.7E+00
SB 18	18	100%	520	65	100	1.9E+00	7.7E-02	6.1E-01
SB 22	22	100%	1,649	65	100	6.0E+00	2.4E-01	1.9E+00
SB 30	30	100%	537	65	100	2.6E+00	1.1E-01	8.6E-01
SB 40	40	100%	318	65	100	1.5E+00	6.3E-02	5.1E-01
SB 41	41	100%	334	65	100	1.6E+00	6.6E-02	5.3E-01

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
SB 44	44	100%	3,080	65	100	1.5E+01	6.1E-01	4.9E+00
SC 22	22	50%	291	255	60	6.3E-01	2.6E-02	2.1E-01
SC 27	27	50%	435	305	60	3.5E+00	1.4E-01	1.1E+00
SC 65	65	100%	4,215	285	60	3.2E+01	1.3E+00	1.1E+01
SRB 30	30	100%	358	255	100	3.0E+00	1.2E-01	1.0E+00
SSBN 726	560	100%	1,252,800	183	2	4.5E+03	1.8E+02	1.5E+03
ST 44	44	100%	7,700	65	100	3.7E+01	1.5E+00	1.2E+01
ST 900	59	100%	15,024	285	60	1.1E+02	4.7E+00	3.8E+01
T-AE 26	564	100%	379,680	245	20	2.1E+03	8.3E+01	6.8E+02
T-AFS 1	581	100%	140,790	245	20	7.6E+02	3.1E+01	2.5E+02
T-AFS 8	524	100%	137,337	245	20	7.4E+02	3.0E+01	2.5E+02
T-AG 195	247	100%	59,126	145	20	2.1E+02	8.4E+00	6.8E+01
T-AGM 23	564	100%	47,791	275	40	3.2E+02	1.3E+01	1.1E+02
T-AGOS 1	224	100%	56,670	145	20	2.0E+02	8.0E+00	6.5E+01
T-AGOS 19	232	100%	53,360	145	20	1.9E+02	7.6E+00	6.2E+01
T-AGOS 23	282	100%	19,691	145	20	6.9E+01	2.8E+00	2.3E+01
T-AGS 45	442	100%	36,590	245	20	2.0E+02	8.0E+00	6.5E+01
T-AGS 51	208	100%	20,170	245	20	1.1E+02	4.4E+00	3.6E+01
T-AGS 60	329	100%	116,298	245	20	6.3E+02	2.6E+01	2.1E+02
T-AH 19	894	100%	247,724	315	20	1.7E+03	6.8E+01	5.5E+02
T-AKR 287	947	100%	893,200	295	20	5.7E+03	2.3E+02	1.9E+03
T-AKR 295	907	100%	428,112	295	20	2.7E+03	1.1E+02	9.0E+02
T-AKR 300	950	100%	830,158	295	20	5.3E+03	2.1E+02	1.7E+03
T-AKR 310	950	100%	955,168	295	20	6.1E+03	2.5E+02	2.0E+03
T-AO 187	677	100%	578,643	295	20	3.7E+03	1.5E+02	1.2E+03
T-ARC 7	503	100%	41,176	245	20	2.2E+02	9.0E+00	7.4E+01
T-ATF 166	226	100%	68,388	245	20	3.7E+02	1.5E+01	1.2E+02
TC 27	27	50%	145	305	60	1.2E+00	4.7E-02	3.8E-01
TC 28	28	50%	156	305	60	1.2E+00	5.1E-02	4.1E-01
TC 42	42	100%	351	215	100	2.7E+00	1.1E-01	8.9E-01
TC 43	43	100%	368	215	100	2.8E+00	1.2E-01	9.4E-01
TC 49	49	100%	478	215	100	3.7E+00	1.5E-01	1.2E+00
TPSB 25	25	50%	1,984	245	100	1.6E+01	6.7E-01	5.4E+00
TR 100	100	100%	5,862	305	5	3.5E+01	1.4E+00	1.2E+01
TR 120	120	100%	12,762	305	5	7.7E+01	3.1E+00	2.5E+01
TR 72	72	100%	3,105	295	5	1.8E+01	7.3E-01	6.0E+00
U 22	22	100%	291	150	65	6.9E-01	2.8E-02	2.2E-01
U 24	24	100%	115	290	65	2.7E-01	1.1E-02	8.8E-02
U 25	25	100%	124	290	65	9.8E-01	4.0E-02	3.2E-01
U 31	31	100%	191	290	65	1.5E+00	6.1E-02	5.0E-01
UB 10	33	50%	648	300	65	5.2E+00	2.1E-01	1.7E+00
UB 12	39	50%	604	195	150	5.5E+00	2.3E-01	1.8E+00
UB 15	49	100%	17,686	195	150	1.6E+02	6.6E+00	5.3E+01
UB 21	21	50%	176	195	150	9.6E-01	3.9E-02	3.1E-01
UB 22	22	50%	7,857	195	150	4.3E+01	1.7E+00	1.4E+01
UB 25	25	50%	868	195	150	8.0E+00	3.2E-01	2.6E+00
UB 27	27	50%	870	195	150	8.0E+00	3.2E-01	2.6E+00
UB 28	28	50%	156	195	150	1.4E+00	5.8E-02	4.7E-01
UB 32	32	50%	203	195	150	1.9E+00	7.6E-02	6.1E-01
UB 33	33	50%	648	195	150	5.9E+00	2.4E-01	1.9E+00

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
UB 40 (MSC)	40	100%	318	195	150	2.9E+00	1.2E-01	9.6E-01
UB 40 (Navy)	40	100%	4,134	195	150	3.8E+01	1.5E+00	1.2E+01
UB 50	50	100%	11,952	195	150	1.1E+02	4.5E+00	3.6E+01
UTL 16	16	50%	0	195	150	0.0E+00	0.0E+00	0.0E+00
UTL 17	17	50%	58	195	150	3.2E-01	1.3E-02	1.0E-01
UTL 18	18	50%	195	195	150	1.1E+00	4.3E-02	3.5E-01
UTL 19	19	50%	72	195	150	3.9E-01	1.6E-02	1.3E-01
UTL 20	20	50%	0	195	150	0.0E+00	0.0E+00	0.0E+00
UTL 21	21	50%	528	195	150	2.9E+00	1.2E-01	9.3E-01
UTL 22	22	50%	485	195	150	2.6E+00	1.1E-01	8.6E-01
UTL 23	23	50%	1,155	195	150	6.3E+00	2.6E-01	2.0E+00
UTL 24	24	50%	460	195	150	2.5E+00	1.0E-01	8.1E-01
UTL 25	25	50%	496	195	150	4.5E+00	1.9E-01	1.5E+00
UTL 26	26	50%	134	195	150	1.2E+00	5.0E-02	4.0E-01
UTL 27	27	50%	725	195	150	6.6E+00	2.7E-01	2.2E+00
UTL 28	28	50%	156	195	150	1.4E+00	5.8E-02	4.7E-01
UTL 36	36	50%	0	195	150	0.0E+00	0.0E+00	0.0E+00
UTM 27	27	50%	435	195	150	4.0E+00	1.6E-01	1.3E+00
UTM 30	30	50%	0	195	150	0.0E+00	0.0E+00	0.0E+00
WB 110	110	100%	2,536	195	150	2.3E+01	9.5E-01	7.6E+00
WB 135	135	100%	7,671	275	60	5.7E+01	2.3E+00	1.9E+01
WB 15	49	100%	5,736	195	150	5.3E+01	2.1E+00	1.7E+01
WB 180	180	100%	7,534	215	150	7.2E+01	2.9E+00	2.4E+01
WB 20	20	50%	80	195	150	4.4E-01	1.8E-02	1.4E-01
WB 24	24	50%	3,220	195	150	1.8E+01	7.1E-01	5.7E+00
WB 25	25	50%	124	195	150	1.1E+00	4.6E-02	3.7E-01
WB 26	26	50%	134	195	150	1.2E+00	5.0E-02	4.0E-01
WB 27	27	50%	145	195	150	1.3E+00	5.4E-02	4.4E-01
WB 28	28	50%	156	195	150	1.4E+00	5.8E-02	4.7E-01
WB 30	30	50%	358	195	150	3.3E+00	1.3E-01	1.1E+00
WB 31	31	50%	191	195	150	1.8E+00	7.1E-02	5.7E-01
WB 34	34	50%	230	195	150	2.1E+00	8.6E-02	6.9E-01
WB 35	35	50%	2,430	195	150	2.2E+01	9.1E-01	7.3E+00
WB 41	41	100%	668	195	150	6.1E+00	2.5E-01	2.0E+00
WB 45	45	100%	2,015	195	150	1.8E+01	7.5E-01	6.1E+00
WB 50	50	100%	36,852	195	150	3.4E+02	1.4E+01	1.1E+02
WB 56	56	100%	625	195	150	5.7E+00	2.3E-01	1.9E+00
WB 74	74	100%	19,236	195	150	1.8E+02	7.2E+00	5.8E+01
WH 12	12	50%	30	55	60	6.5E-02	2.7E-03	2.1E-02
WH 16	16	100%	312	55	60	6.8E-01	2.8E-02	2.2E-01
WHEC 378	379	100%	208,068	116	26	6.6E+02	2.7E+01	2.2E+02
WIX 180	180	100%	6,751	135	100	4.2E+01	1.7E+00	1.4E+01
WIX 295	295	100%	12,264	196	36	6.2E+01	2.5E+00	2.0E+01
WLB 180	180	50%	20,253	135	100	1.3E+02	5.1E+00	4.1E+01
WLB 225	225	100%	144,998	135	100	9.0E+02	3.7E+01	3.0E+02
WLI 65 303	65	100%	1,037	146	205	1.1E+01	4.3E-01	3.5E+00
WLI 65 400	65	100%	2,284	146	205	2.3E+01	9.5E-01	7.6E+00
WLIC 100	100	100%	2,432	146	205	2.5E+01	1.0E+00	8.1E+00

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
WLIC 160	160	100%	20,452	146	205	2.1E+02	8.5E+00	6.8E+01
WLIC 75	75	100%	14,024	146	205	1.4E+02	5.8E+00	4.7E+01
WLM 133	133	100%	4,648	149	150	3.9E+01	1.6E+00	1.3E+01
WLM 175	175	100%	83,304	123	200	8.0E+02	3.3E+01	2.6E+02
WMEC 210	210	100%	111,200	176	12	4.2E+02	1.7E+01	1.4E+02
WMEC 213	213	100%	8,337	176	12	3.2E+01	1.3E+00	1.0E+01
WMEC 230	230	100%	8,621	176	12	3.3E+01	1.3E+00	1.1E+01
WMEC 270	270	100%	142,688	176	12	5.4E+02	2.2E+01	1.8E+02
WMEC 282	282	100%	14,191	176	12	5.4E+01	2.2E+00	1.8E+01
WPB 110	110	100%	106,379	127	200	1.0E+03	4.2E+01	3.4E+02
WPB 82	83	100%	2,486	297	30	1.7E+01	6.8E-01	5.6E+00
WPB 87	87	100%	75,700	114	200	7.1E+02	2.9E+01	2.3E+02
WYTL 65	65	100%	12,996	38	300	1.5E+02	6.2E+00	4.9E+01
YC 1026	150	100%	17,320	295	60	1.4E+02	5.5E+00	4.5E+01
YC 1321	125	100%	12,316	295	60	9.6E+01	3.9E+00	3.2E+01
YC 1351	81	100%	3,051	295	60	2.4E+01	9.7E-01	7.9E+00
YC 1366	110	100%	30,850	295	60	2.4E+02	9.8E+00	8.0E+01
YC 1389	160	100%	11,536	295	60	9.0E+01	3.7E+00	3.0E+01
YC 1427	110	100%	18,132	295	60	1.4E+02	5.8E+00	4.7E+01
YC 1436	120	100%	6,408	295	60	5.0E+01	2.0E+00	1.7E+01
YC 1448	130	100%	11,640	295	60	9.1E+01	3.7E+00	3.0E+01
YC 1461	110	100%	11,584	295	60	9.1E+01	3.7E+00	3.0E+01
YC 1469	110	100%	127,424	295	60	1.0E+03	4.0E+01	3.3E+02
YC 1500	110	100%	24,680	295	60	1.9E+02	7.8E+00	6.4E+01
YC 1517	110	100%	208,512	295	60	1.6E+03	6.6E+01	5.4E+02
YC 1607	110	100%	203,736	295	60	1.6E+03	6.5E+01	5.3E+02
YC 161	110	100%	5,540	295	60	4.3E+01	1.8E+00	1.4E+01
YC 255	110	100%	98,720	295	60	7.7E+02	3.1E+01	2.5E+02
YC 688	110	100%	31,766	295	60	2.5E+02	1.0E+01	8.2E+01
YC 981	142	100%	8,228	295	60	6.4E+01	2.6E+00	2.1E+01
YCV 7	200	100%	51,720	305	60	4.1E+02	1.7E+01	1.4E+02
YD 113	140	100%	76,300	325	30	5.6E+02	2.3E+01	1.8E+02
YD 120	140	100%	30,636	325	30	2.2E+02	9.1E+00	7.4E+01
YD 150	198	100%	14,876	325	30	1.1E+02	4.4E+00	3.6E+01
YD 159	120	100%	9,360	325	30	6.8E+01	2.8E+00	2.3E+01
YD 210	142	100%	31,908	325	30	2.3E+02	9.5E+00	7.7E+01
YD 222	142	100%	9,986	325	30	7.3E+01	3.0E+00	2.4E+01
YD 223	140	100%	50,960	325	30	3.7E+02	1.5E+01	1.2E+02
YD 232	142	100%	31,908	325	30	2.3E+02	9.5E+00	7.7E+01
YD 243	140	100%	11,036	325	30	8.1E+01	3.3E+00	2.7E+01
YD 246	175	100%	145,125	325	30	1.1E+03	4.3E+01	3.5E+02
YD 247	175	100%	75,625	325	30	5.5E+02	2.2E+01	1.8E+02
YFN 1154	110	100%	18,510	295	60	1.4E+02	5.9E+00	4.8E+01
YFN 1172	110	100%	13,260	295	60	1.0E+02	4.2E+00	3.4E+01
YFN 1173	110	100%	28,780	295	60	2.2E+02	9.1E+00	7.4E+01
YFN 1196	110	100%	46,336	295	60	3.6E+02	1.5E+01	1.2E+02
YFN 1239	110	100%	11,584	295	60	9.1E+01	3.7E+00	3.0E+01
YFN 1254	110	100%	86,380	335	0	5.5E+02	2.2E+01	1.8E+02

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
YFN 1277	110	100%	43,190	295	60	3.4E+02	1.4E+01	1.1E+02
YFN 161	110	100%	191,270	295	60	1.5E+03	6.1E+01	4.9E+02
YFNB 2	260	100%	108,144	295	60	8.5E+02	3.4E+01	2.8E+02
YFNB 47	152	100%	7,728	295	60	6.0E+01	2.5E+00	2.0E+01
YFND 5	110	100%	17,640	305	60	1.4E+02	5.7E+00	4.7E+01
YFNX 15	110	100%	5,468	295	60	4.3E+01	1.7E+00	1.4E+01
YFNX 20	110	100%	4,538	295	60	3.5E+01	1.4E+00	1.2E+01
YFNX 24	110	100%	5,792	295	60	4.5E+01	1.8E+00	1.5E+01
YFNX 30	110	100%	5,180	295	60	4.0E+01	1.6E+00	1.3E+01
YFNX 31	110	100%	5,346	295	60	4.2E+01	1.7E+00	1.4E+01
YFNX 35	153	100%	8,025	295	60	6.3E+01	2.5E+00	2.1E+01
YFNX 36	110	100%	5,918	295	60	4.6E+01	1.9E+00	1.5E+01
YFNX 39	110	100%	5,918	295	60	4.6E+01	1.9E+00	1.5E+01
YFNX 40	110	100%	5,792	295	60	4.5E+01	1.8E+00	1.5E+01
YFNX 42	110	100%	6,170	295	60	4.8E+01	2.0E+00	1.6E+01
YFNX 43	110	100%	6,076	295	60	4.7E+01	1.9E+00	1.6E+01
YFNX 44	127	100%	6,713	295	60	5.2E+01	2.1E+00	1.7E+01
YFU 71	125	100%	7,076	155	200	7.2E+01	2.9E+00	2.4E+01
YFU 91	115	100%	5,525	155	200	5.6E+01	2.3E+00	1.8E+01
YGN 80	124	100%	22,560	305	60	1.8E+02	7.3E+00	6.0E+01
YL 30	30	50%	179	65	100	8.7E-01	3.6E-02	2.9E-01
YLC 1	110	100%	5,224	325	30	3.8E+01	1.5E+00	1.3E+01
YLC 2	110	100%	4,088	325	30	3.0E+01	1.2E+00	9.9E+00
YMN 1	154	100%	6,330	305	60	5.1E+01	2.1E+00	1.7E+01
YNG 1	110	100%	9,784	305	60	7.8E+01	3.2E+00	2.6E+01
YOGN 106	165	100%	51,210	205	150	4.8E+02	2.0E+01	1.6E+02
YOGN 123	230	100%	14,012	205	150	1.3E+02	5.3E+00	4.3E+01
YOGN 8	165	100%	17,950	205	150	1.7E+02	6.8E+00	5.5E+01
YON 245	165	100%	177,840	205	150	1.7E+03	6.8E+01	5.5E+02
YON 307	184	100%	119,020	205	150	1.1E+03	4.5E+01	3.7E+02
YON 89	165	100%	26,925	205	150	2.5E+02	1.0E+01	8.3E+01
YOS 14	110	100%	6,332	200	145	5.7E+01	2.3E+00	1.9E+01
YOS 33	165	100%	26,925	200	145	2.4E+02	1.0E+01	8.0E+01
YOS 4	110	100%	6,332	200	145	5.7E+01	2.3E+00	1.9E+01
YP 654	81	100%	2,102	195	150	1.9E+01	7.8E-01	6.3E+00
YP 676	108	100%	46,641	205	150	4.4E+02	1.8E+01	1.4E+02
YPD 45	110	100%	6,044	330	30	4.5E+01	1.8E+00	1.5E+01
YR 24	150	100%	30,528	330	39	2.4E+02	9.6E+00	7.8E+01
YR 26	153	100%	38,880	280	30	2.5E+02	1.0E+01	8.3E+01
YR 83	111	100%	4,176	330	30	3.1E+01	1.3E+00	1.0E+01
YR 84	210	100%	14,700	330	30	1.1E+02	4.4E+00	3.6E+01
YR 92	110	100%	4,320	330	30	3.2E+01	1.3E+00	1.1E+01
YR 93	261	100%	18,090	330	30	1.3E+02	5.4E+00	4.4E+01
YR 94	261	100%	18,090	330	30	1.3E+02	5.4E+00	4.4E+01
YRB 25	110	100%	4,892	325	30	3.6E+01	1.4E+00	1.2E+01
YRB 29	124	100%	7,688	325	30	5.6E+01	2.3E+00	1.9E+01
YRB 30	261	100%	36,180	325	30	2.6E+02	1.1E+01	8.7E+01
YRB 31	150	100%	15,264	325	30	1.1E+02	4.5E+00	3.7E+01
YRB 32	153	100%	15,264	325	30	1.1E+02	4.5E+00	3.7E+01
YRB 33	150	100%	15,264	325	30	1.1E+02	4.5E+00	3.7E+01
YRBM 1	110	100%	4,604	325	30	3.4E+01	1.4E+00	1.1E+01

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft2)	Days in Port	Days Underway	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
YRBM 20	261	100%	18,090	325	30	1.3E+02	5.4E+00	4.4E+01
YRBM 23	146	100%	66,016	325	30	4.8E+02	2.0E+01	1.6E+02
YRBM 31	146	100%	132,032	325	30	9.6E+02	3.9E+01	3.2E+02
YRBM 48	150	100%	15,264	325	30	1.1E+02	4.5E+00	3.7E+01
YRBM 49	150	100%	15,264	325	30	1.1E+02	4.5E+00	3.7E+01
YRBM 5	112	100%	26,080	325	30	1.9E+02	7.7E+00	6.3E+01
YRBM 50	150	100%	18,304	325	30	1.3E+02	5.4E+00	4.4E+01
YRBM 51	153	100%	15,552	325	30	1.1E+02	4.6E+00	3.8E+01
YRBM 52	150	100%	15,264	325	30	1.1E+02	4.5E+00	3.7E+01
YRBM 53	150	100%	15,264	325	30	1.1E+02	4.5E+00	3.7E+01
YRDH 1	153	100%	7,611	305	60	6.1E+01	2.5E+00	2.0E+01
YRDM 1	153	100%	7,611	330	30	5.6E+01	2.3E+00	1.9E+01
YRR 11	151	100%	22,551	325	30	1.6E+02	6.7E+00	5.4E+01
YRR 2	153	100%	7,776	325	30	5.7E+01	2.3E+00	1.9E+01
YRR 5	150	100%	7,632	325	30	5.6E+01	2.3E+00	1.8E+01
YSD 11	104	100%	4,304	295	60	3.4E+01	1.4E+00	1.1E+01
YSR 30	110	100%	12,920	255	100	1.1E+02	4.5E+00	3.6E+01
YTB 760	109	100%	62,035	285	60	4.7E+02	1.9E+01	1.6E+02
YTL 422	66	100%	1,015	295	60	7.9E+00	3.2E-01	2.6E+00
YTT 9	186	100%	24,824	305	60	2.0E+02	8.1E+00	6.6E+01
YWN 60	165	100%	8,975	305	60	7.2E+01	2.9E+00	2.4E+01

Table B-3. Saltwater Mass Loadings for the Baseline Discharge from the Flexible Hulls Vessel Group

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft^2)	Days in Port	Days Underway Within 12 nm	Total Cu Released (lb/yr)	Total Fe Released (lb/yr)	Total Zn Released (lb/yr)
MCM 1	217	100%	8,410	233	9	3.8E+01	1.9E+00	1.5E+01
SSN 21	353	100%	139,200	183	2	4.7E+02	2.3E+01	1.9E+02
SSN 688	360	100%	1,922,700	183	2	6.5E+03	3.2E+02	2.6E+03
SSN 774	377	100%	153,200	183	2	5.2E+02	2.6E+01	2.1E+02

Table B-4. Freshwater Mass Loadings for the Baseline Discharge from the Aluminum Hulls Vessel Group

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft^2)	Days in Port	Days Underway	Total Sea-Nine Released (lb/yr)	Total Zn Released (lb/yr)
ANB(X) 34	34	50%	230	235	100	2.6E-01	1.2E+00
MLB 47	47	100%	6,160	305	30	1.0E+00	6.5E+01
TANB 21 CI	21	50%	352	245	100	1.2E-01	5.5E-01
TANB 21 SI IB	21	50%	264	245	100	8.8E-02	4.1E-01
UTB 41	41	100%	6,680	95	263	7.9E+00	7.5E+01
UTL 17	17	50%	232	195	150	1.2E-01	5.5E-01
UTL 18	18	50%	65	195	150	2.9E-02	1.4E-01
UTL 20	20	50%	80	195	150	4.0E-02	1.9E-01
UTL 21	21	50%	176	195	150	8.8E-02	4.1E-01
UTL 22	22	50%	97	195	150	4.8E-02	2.3E-01
UTL 23	23	50%	525	195	150	2.6E-01	1.2E+00
UTL 24	24	50%	115	195	150	5.7E-02	2.7E-01
UTL 25	25	50%	124	195	150	1.4E-01	6.7E-01
UTM 27	27	50%	145	195	150	1.7E-01	7.8E-01
UTM 28	28	50%	156	195	150	1.8E-01	8.4E-01
UTM 30	30	50%	358	195	150	4.1E-01	1.9E+00

Table B-5. Saltwater Mass Loadings for the Baseline Discharge from the Aluminum Hulls Vessel Group

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft^2)	Days in Port	Days Underway	Total Sea-Nine Released (lb/yr)	Total Zn Released (lb/yr)
ANB 55	58	100%	12,078	255	110	1.5E+01	1.4E+02
ANB(X) 34	34	100%	230	235	100	2.6E-01	2.4E+00
ANB(X) 38	38	100%	287	235	100	3.2E-01	3.0E+00
ATB 41	41	100%	1,002	255	100	1.2E+00	1.1E+01
BH 22	22	50%	97	255	60	1.9E-02	9.1E-02
FB	65	100%	843	275	30	8.5E-01	8.1E+00
IMARV 50	50	100%	498	255	100	5.9E-01	5.5E+00
MLB 47	47	100%	36,960	305	30	4.1E+01	3.9E+02
TANB 21 CI	21	50%	1,056	245	100	3.5E-01	1.7E+00
TANB 21 SI IB	21	50%	1,320	245	100	4.4E-01	2.1E+00
TANB 21 SI OB	21	50%	264	245	100	8.8E-02	4.1E-01
TANB 23	23	50%	105	245	100	3.5E-02	1.6E-01
TPSB 22	22	50%	194	245	100	6.4E-02	3.0E-01
UTB 41	41	100%	47,762	95	263	5.7E+01	5.4E+02

Vessel Class	Length (ft)	Coating Use	Class Wetted Surface Area (ft^2)	Days in Port	Days Underway	Total Sea-Nine Released (lb/yr)	Total Zn Released (lb/yr)
UTL 13	13	50%	35	95	263	3.1E-02	1.4E-01
UTL 15	15	50%	46	195	150	2.3E-02	1.1E-01
UTL 16	16	50%	52	195	150	2.6E-02	1.2E-01
UTL 17	17	50%	58	195	150	2.9E-02	1.4E-01
UTL 18	18	50%	195	195	150	9.7E-02	4.6E-01
UTL 19	19	50%	72	195	150	3.6E-02	1.7E-01
UTL 20	20	50%	80	195	150	4.0E-02	1.9E-01
UTL 21	21	50%	528	195	150	2.6E-01	1.2E+00
UTL 22	22	50%	485	195	150	2.4E-01	1.1E+00
UTL 23	23	50%	1,260	195	150	6.3E-01	3.0E+00
UTL 24	24	50%	460	195	150	2.3E-01	1.1E+00
UTL 25	25	50%	496	195	150	2.5E-01	1.2E+00
UTL 26	26	50%	134	195	150	1.5E-01	7.2E-01
UTL 27	27	50%	725	195	150	8.3E-01	3.9E+00
UTL 28	28	50%	156	195	150	1.8E-01	8.4E-01
UTL 36	36	50%	258	195	150	3.0E-01	1.4E+00
UTM 27	27	50%	435	195	150	5.0E-01	2.4E+00
UTM 30	30	50%	179	195	150	2.0E-01	9.7E-01